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ABSTRACT

This final report describes the development of eight computer based science simulations designed for use with middle school mainstreamed students having learning disabilities or mild mental retardation. The total program includes software, a teacher's manual, 3 videos, and a set of 30 activity worksheets. Special features of the software for learners with cognitive impairments include an emphasis on graphics rather than text to present key ideas; the use of a mouse instead of a keyboard for giving commands and manipulating the experiments; the absence of a formal reward/punishment system; the presence of simple numeric feedback for confirming measurements; the use of full size scales on the display instruments; voice synthesis of numerical output on demand; a context sensitive help function; and flexible problem solving environments for each simulation. The report lists the project's objectives, results (including field test evaluation and dissemination), and project methodology. The major portion of the document consists of appendices including the teacher's manual and the activity worksheets covering the eight simulations of the following: the physical science laboratory, finding elapsed time, finding length and width, finding area, finding distance using a map, finding seasonal temperatures, and experiments concerned with refrigerators and the pendulum. Teacher and student evaluation forms are also appended. (Nine references) (DB)

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G008730289

ED346653

# Final Report

# Development of Science Simulations for Mildly Mentally Retarded or Learning Disabled Students

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Improving Technology Software

Submitted to:

Office of Special Education Programs
U.S. Department of Education

by:

Macro Systems, Inc.

September 1989

EC 301265

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# Abstract

Macro Systems, Inc., under a grant from the U.S. Department of Education, Office of Special Education Programs, has developed a series of eight science simulations designed to complement any middle-school physical science curriculum. The simulations are specifically intended to help learning disabled students who have been mainstreamed into a typical science education environment. The simulations have been carefully constructed to appeal to students with a wide variety of reasoning skills, while maintaining features that will be especially helpful to the learning impaired child. The software is accompanied by a Teacher's Manual; three videos that can be used to introduce the materials to both students and teachers; and a set of 30 Activity Worksheets to be used with the software.

Special features of the software for cognitively impaired learners include an emphasis on graphics rather than text to present key ideas; the use of a mouse instead of a keyboard for giving commands and manipulating the experiments; the absence of a formal reward/ punishment system; the presence of easy-to-read numeric feedback for confirming measurements; the use of full-size scales on the display instruments; voice synthesis of numerical output on demand; a context-sensitive help function that responds when one points at an object or location on the screen in question; flexible problem-solving environments for each simulation that can be approached at different cognitive levels.

# Chapter I

# Introduction

# Chapter I. Introduction

When the Technology, Educational Media and Materials for the Handicapped Grant Program was first announced in April of 1987, a cover letter written by Dr. James Johnson, Chief, Research and Development Projects Branch appeared in the application package:

> This office is committed to improving the education, independent functioning, and employment of handicapped individuals by assuring that the advances of technology, educational media, and materials are available, of good quality, and used appropriately. Even with the growing number of new technologies available in the schools today, there exists a need to support planning, research, and development activities to provide for more efficient and effective use of these state-of-the-art technological advances. Past research has shown that when technology is made available and used knowledgeably it has enormous potential for improving the education, independence and employability of individuals with handicaps. Accordingly, projects will be invited that provide for research, development, and/or dissemination activities related to the use of technology in the delivery of services to individuals with handicaps.

The impetus behind this solicitation was clear. Few publishers or commercial software developers have been willing to risk the capital investment necessary to produce technology products geared to the needs of students with special learning needs. The special education market is viewed as a "thin" market and stereotypic ideas of what constitutes a special education student preclude mainstream publishers from thinking otherwise.

Macro submitted an application under the priority area "Improving Technology Software." In our proposal to the Office of Special Education Programs, we responded to the language of the announcement that " Computer simulations of science experiments, and situations involving math and language arts are encouraged."

Key features of the proposal included:

- Development of a series of simulation models illustrating scientific principles with specific features to accommodate the needs of mildly mentally retarded or learning disabled students to progress in ability-integrated middle school physical science courses.
- Software focused on developing skills required in solving many types of problems - classifying, contrasting, hypothesizing, estimating, etc.
- A software design consisting of a series of independent simulations that would share a common user interface. "Point and click" methods to be used to control each of the simulations.

- Primary emphasis on the creation of user controls that are as simple and consistent as possible. Simple methods of starting, stopping, restarting, and changing simulations to be employed.

- Development of the software to be guided by a design team with the appropriate expertise. In addition to the software, a Teacher's Guide and a teacher's utility program to be developed.

- Field testing at two sites in the Chittenden South School District in Chittenden County, Vermont.

- Dissemination either as a commercial product or as free public domain shareware. Commercial publishers to be contacted for the purpose of having them evaluate and publish the software.

## I. Objectives 1: To Design the Models Program

Activities to include finalizing members of the design team; reviewing existing simulation software; and convening a meeting of the design team.

## II. Objective 2: Prepare Detailed Specifications

Create storyboards for the programs; review storyboards with the design team; revise storyboards as needed; prepare detailed system specifications; prepare detailed module specifications; and conduct software quality assurance.

## III. Objective 3: Write and Debug the Programs

Assemble and/or acquire the necessary hardware and software; do the programming; prepare a teacher's guide; and conduct subsystem tests.

## IV. Objective 4: Conduct Field Test at Two Sites

Finalize field test plan; orient teachers in their schools; and collect formative evaluation data.

## V. Objective 5: To Plan for National Dissemination and Distribution

Demonstrate the product to potential publishers; investigate public domain distribution; and prepare marketing plan component.

# Chapter II

# Results

# I. Instructional Material Produced

## A. The Simulation Software

### 1) Characteristics

#### a) General Description

The series of science simulations we developed, titled "The Physical Science Laboratory," has been created to allow students to perform physical science experiments in a completely simulated experimental environment. The software is intended to complement any middle school physical science curriculum. The simulations allow a student to perform physical science experiments using an Apple II/GS or IBM compatible computer system[1]; no external experimental equipment is required. Using a "mouse," the student manipulates objects on the computer screen to affect the outcome of each experiment. The simulations are open-ended and experiments may be carried out in a structured or unstructured fashion to suit a particular teaching methodology.

Some of the objects and situations presented on the computer screen are similar to those that the student will encounter in the school laboratory; others place the student in familiar environments outside the school; still others exploit the computer's potential to create interesting experimental environments that would not normally be available to the student.

Problem sets have been developed (see the Activity Worksheets) for each simulation. The skills required to solve the problems start at the level of simple observation and advance through levels such as classifying, measuring, generalizing and predicting. A number of simulations are designed to help students gain competence in doing basic measurements. A consistent interface is used throughout all of the simulations.

#### b) Target Audience

The science simulations are suitable for students with a wide variety of cognitive reasoning skills. Care has been taken to design the software to meet the needs of middle school-aged learning disabled and mildly mentally retarded students, particularly those who have been mainstreamed:

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[1] The IBM compatible configuration must include VGA or EGA graphics capability, and a COVOX "Speech Thing" attached to the parallel printer port.

### c) Special Features for Learning Impaired Students

Special features for learning impaired students include an emphasis on graphics rather than text to present key ideas; the use of a mouse instead of a keyboard for giving commands and for manipulating the experiments; the presentation of feedback in a non-judgmental manner, i.e., the absence of a formal reward/punishment system; voice synthesis of experimental data when requested by the user; a context sensitive help function that responds when the user points (with the mouse) to the object or location in question; the use of practical, familiar situations to introduce basic concepts; and a series of problem-solving environments that can be approached at different cognitive levels.

### d) Technical Objectives Achieved

1. The software provides a simple and common interface to manage the simulations. The interface is mouse-driven to avoid having to type in commands at the keyboard. The use of a mouse facilitates cursor movement for selecting various options at different positions on the screen, and for positioning experimental objects.

2. The software maintains technical accuracy in depicting physical events. Observations and data obtained during these experiments are similar to those that would be obtained if the experiment were done under the same conditions in a real-world environment. Care has been taken to introduce numbers that reflect physical laws as they are currently understood.

3. For those experiments that exhibit dynamic behavior, the software gives the user control over the rate at which events occur during the experiments. The simulated laboratory environment includes a clock that can be used to speed up or slow down time. Speeding up or slowing down the laboratory clock relative to a real world clock will cause the events occurring in the laboratory to speed up or slow down accordingly. Time can be stopped altogether to allow critical measurements to be obtained, or to position experimental objects in space.

## 2) Modules

### a) Experiment 0: The Physical Science Laboratory

**Objectives**

This simulation is designed to point out the important features of the Physical Science Laboratory that are common to all the experiments. The names of the various locations in the simulated laboratory are introduced. Descriptions of the program's features are available using the HELP facility.

**General Description**

The Physical Science Laboratory enables the student or teacher to perform physical science experiments in a simulated experimental environment. The experiments take place on the computer screen. All the equipment and measurement instruments are part of the simulation; no external devices are necessary.

Experiments take place on the "lab bench," a rectangular area occupying the majority of the screen. The picture displayed in this area varies for different experiments. For instance, it can appear as a table top (thus the "lab bench" designation) in one experiment or as an outdoor scene in another.

At the top of the screen are four "instrument windows" that contain icons representing various pieces of equipment and measuring tools. (Icons are small pictures that can "dragged" about the screen using the mouse.) One of the windows is reserved for the elapsed-time clock, which appears in every experiment. Each instrument window also contains a "value bar" and a "units bar" where numeric and textual information pertaining to the instrument are displayed.

Using only the mouse as an input device, experimental objects are manipulated, time is controlled, and measurements are taken. The numerical values of the measurements appear in the value bars of the various instrument windows as the measurement process is taking place. The data generated from these simulations can be recorded and analyzed in the same fashion as data from any real-world experiment.

## b) Experiment 1: Finding Elapsed Time

### Objectives

This simulation is designed to help students learn how to use the elapsed-time clock in the Physical Science laboratory. Students will learn how to start, stop and reset the elapsed-time clock. They will learn how to read the time from the value bar and interpret the units in which time is given in the units bar. They will also learn how to speed up and slow down time using the clock speed-control. Students will acquaint themselves with their own internal sense of time and how it is affected by environmental conditions. This experiment can also be used to help students learn to read the elapsed-time associated with the positions of the hands on a conventional analog clock.

### General Description

This environment features a large analog clock resting on the lab bench. The large clock corresponds to the clock icon pictured in the clock instrument window. The large clock can be started, stopped and reset by clicking (with the mouse) on one of the appropriate "buttons" surrounding it. Hands on the large clock--corresponding to the units selected via the units bar--move when the clock is running. Units of time in hours and minutes, minutes and seconds, or seconds and tenths of seconds are available.

In addition to the traditional analog clock, the student may select from among three different sand-in-glass timers for keeping track of time; minute, second, and hour-glass timers are available. The flow of sand through the timers speeds up or slows down as the position of the clock speed-control is changed.

## c) Experiment 2: Finding Length and Width

### Objectives

This simulation is designed to help students learn how to read the different scales associated with a ruler, as well as to learn how to use the ruler instrument in the Physical Science Laboratory. The student will learn to read several different scales that show length in units of inches by tenths, inches by eighths, millimeters, and centimeters.

### General Description

The ruler instrument is used to make length measurements of the objects located on the lab bench. As the student makes the measurements using the ruler icon, the distance being measured is displayed in the value bar of the ruler instrument window. At the same time a pointer indicates the distance on a full-sized ruler shown on the screen. The student may choose to show or hide the number displayed in the value bar. If the value is not hidden, then when the measurement is completed it will be spoken by the computer.

Learning to read the different scales of a ruler is a matter of making a length measurement, looking at the ruler scale, and interpreting the results. The program provides constant feedback to the student by showing the scale value while simultaneously displaying the corresponding numerical value. Additional reinforcement is accomplished through the use of voice synthesis.

## d) Experiment 3: Finding Area

### Objectives

This simulation is designed to help students learn how to read the scales associated with a ruler, while at the same time allowing the student to explore the concept of area measurement. The student will be able to vary and measure the dimensions of a circle, a rectangle, and a right triangle. The student will learn how to compute the area of each of these figures.

### General Description

The ruler instrument is used to make length measurements of the geometric figures located on the lab bench. As the student makes measurements with the ruler icon, the distance being measured is displayed in the value bar of the ruler instrument window. At the same time a pointer depicts the same distance on a full-sized ruler shown on the screen. The student may choose to show or hide the number displayed in the value bar. If the value bar is not hidden (by having clicked on it previously) when the measurement is completed, the measurement will be spoken by the computer.

Three geometric figures appear on the lab bench. The size of each geometric figure can be changed by "dragging" the mouse pointer along the edge of the figure. The area of the figure being manipulated also appears in the value bar of an instrument window. This number can be hidden (or made visible) by simply clicking on the value bar in which it appears.

## e) Experiment 4: Finding Distance Using a Map

### Objectives

This simulation is designed to help students learn how to read the scales associated with a ruler. Using the ruler instrument, students will learn how to measure distances on a map in inches, and convert these measurements into units of miles. (Metric units are also available.) This simulation will help the student make the transition from concrete to abstract measurements of spatial dimensions. With computer assistance, if necessary, the student will also learn how to measure distances along roads using a paper map.

### General Description

The ruler instrument is used to make distance measurements on a map shown on the lab bench. The student uses the ruler icon to make measurements, and the distance being measured is displayed in the value bar of the ruler instrument window. At the same time, a pointer shows the distance being measured on a full-sized ruler at the bottom of the lab bench. The student may choose to show or hide numbers displayed in any of the value bars. If a value bar is not hidden, then when a measurement is completed it measurement will be spoken by the computer.

Measurements are made on a map. By clicking on the units bar of the ruler, the units of measurement can be changed to inches, centimeters, millimeters, miles, or kilometers. The scale of the map can also be shown in miles or in kilometers. Once distance measurements have been completed using the ruler icon, a car icon is available that can be "driven" over the route to provide a rough check on the student's calculations. The distance driven, in miles or kilometers, is displayed in the value bar associated with the car icon. Clicking on the trip odometer icon resets the distance traveled by the car to zero.

## f) Experiment 5: Finding Seasonal Temperatures

### Objectives

This simulation is designed to help students learn how to read the scales associated with a circular thermometer, as well as to learn how to use the thermometer instrument in the Physical Science Laboratory. The student will also be able to examine the daily variation in air and water temperature in a typical New England state throughout an entire year. The student will be able to identify days of the year when the average temperature is at a maximum or minimum, or months of the year when the temperature is changing most rapidly.

### General Description

This environment features a thermometer instrument, an icon that can be moved about the screen to take temperature measurements of the outdoor scene depicted. The average air and water temperature can be measured in the outdoor scene on a daily basis throughout an entire year. Both the month and the day of the month can be selected by the student; the outdoor scene varies to depict the time of year. The temperature read on a given day is equal to the average temperature for that day (the software contains a data base of U.S. Weather Bureau data for the city of Burlington, Vermont). A large circular analog thermometer appears on the lab bench whose reading always corresponds to the digital reading displayed in the thermometer instrument window. The scale can be switched to show either Fahrenheit or Celsius degrees.

## g) Experiment 6: Finding Refrigerator Temperatures

### Objectives

This simulation is designed to help students learn how to read the scales associated with a linear thermometer, as well as to learn how to use the thermometer instrument in the Physical Science Laboratory. The student will also learn about temperature conditions inside a typical refrigerator: how the temperature inside the refrigerator and freezer compartments can be controlled with the refrigerator thermostat and how the temperatures would be affected by a power failure. The student will be able to translate thermostat settings, normally not shown in degrees, into actual temperature settings.

### General Description

This environment allows students to measure temperatures in the refrigerator and freezer compartments of a simulated refrigerator. The student can also control the temperatures in the refrigerator by adjusting the refrigerator thermostat. The thermostat has ten different settings including an OFF position.

The doors of the refrigerator can be opened and closed, and the thermometer icon can be placed inside the refrigerator or the freezer compartment. When the icon is inside a compartment and the door is closed, the temperature displayed in the thermometer instrument window is the average temperature of the contents of that compartment. If the door is opened, the temperature displayed is the temperature of the air in the room.

The left-hand side of the lab bench exhibits a large analog thermometer whose scale is readable to the nearest degree. The liquid in the tube of this thermometer rises and falls with a change in temperature. Two scales are available: Fahrenheit and Celsius. Since the Fahrenheit scale has more divisions than the Celsius scale, the student can use a "zoom in/zoom out" feature to magnify the image of the Fahrenheit scale to afford a more precise reading.

## h) Experiment 7: Pendulum

### Objectives

This simulation is designed to help students learn about the factors that influence the behavior of a pendulum.

### General Description

The simulation allows students to perform experiments with a pendulum. The student can select any of three different pendulum bobs during an experiment. The length of the pendulum can be varied by "pulling" on the cord attached to the pendulum bob. The pendulum experiments can be performed on the earth or on the moon. Measurement instruments are available to measure mass and length as well as elapsed time. A marking pen icon is available to mark the position of the pendulum.

The motion of the pendulum can be stopped at any time. While time is stopped, the pendulum may be positioned at any angular displacement between plus or minus 90 degrees. The pendulum will behave in a periodic manner for small angular displacements and will exhibit non-linear behavior for larger angular displacements. The motion of the pendulum is affected by air resistance while on earth, but air resistance is not a factor on the moon. A small amount of internal friction causes damping of the pendulum motion both on the earth and the moon.

One of the pendulum bobs (a hollow-looking one) can be used to illustrate pendulum motion with only the force of gravity affecting the motion, regardless of whether the experiment is taking place on the earth or on the moon. The chief use of the hollow bob is to illustrate those statements that begin, "Let us assume the absence of any friction."

## B. The Activity Worksheet Series

Each simulation for the Physical Science Laboratory is accompanied by an Activity Worksheet Series. The first of these documents for each simulation is a detailed introduction to the simulation environment presented by the computer program. The remainder of the documents are a series of Activity Worksheets that pose experimental problems to the student. The worksheets are designed to be filled out while solving an experimental problem.

The introductory document for each simulation describes the primary objectives we had in mind when we created the simulation. It also describes the special features associated with that simulation and provides instructions on how to manipulate each instrument or object in the experimental environment. A picture of some phase of the simulation always appears on the first page of the introductory document. There are a total of eight introductory documents in the series.

Each Activity Worksheet to be filled out by the student is identified by a number and a title: for example, "Worksheet 5-3: Changing Temperatures." The number 5-3 indicates that this worksheet is associated with Experiment 5, and is the third in the series. Each Activity Worksheet contains several problems designed to be answered directly on the worksheet. There are a total of 30 worksheets in the series.

The titles and numbers for the complete Activity Worksheet Series are shown below.

Experiment 0: The Physical Science Laboratory
    Introduction to Experiment 0
    Worksheet 0-1: Touring the Physical Science Laboratory
    Worksheet 0-2: Using the Instruments
    Worksheet 0-3: Using Other Instruments

Experiment 1: Finding Elapsed Time
    Introduction to Experiment 1
    Worksheet 1-1: Using the Elapsed Time Clock
    Worksheet 1-2: Making Time Go Faster or Slower
    Worksheet 1-3: Time Sense

Experiment 2: Finding Length and Width
    Introduction to Experiment 2
    Worksheet 2-1: Using the Ruler
    Worksheet 2-2: More Ruler Measurements

Experiment 3: Finding Area
    Introduction to Experiment 3
    Worksheet 3-1: Area of a Rectangle
    Worksheet 3-2: Area of a Circle
    Worksheet 3-3: Area of a Triangle

Experiment 4: Finding Distance Using a Map
    Introduction to Experiment 4
    Worksheet 4-1: Measuring Map Distance
    Worksheet 4-2: Measurement Issues
    Worksheet 4-3: Ruler with 1/10 Inch Scale Divisions
    Worksheet 4-4: Measuring Distances on Paper Maps

Experiment 5: Finding Seasonal Temperatures
    Introduction to Experiment 5
    Worksheet 5-1: Measuring Air and Water Temperatures
    Worksheet 5-2: Temperature Extremes
    Worksheet 5-3: Changing Temperatures
    Worksheet 5-4: Temperature Scales
    Worksheet 5-5: Reading a Circular Thermometer

Experiment 6: Refrigerator
    Introduction to Experiment 6
    Worksheet 6-1: Inside Your Refrigerator
    Worksheet 6-2: Temperatures Inside a Refrigerator
    Worksheet 6-3: Controlling Refrigerator Temperature
    Worksheet 6-4: Knowing Your Refrigerator Thermostat
    Worksheet 6-5: What if the Power Goes Off
    Worksheet 6-6: Reading a Thermometer
    Worksheet 6-7: In Your Own Refrigerator

Experiment 7: Pendulum
    Introduction to Experiment 10
    Worksheet 7-1: Working with the Pendulum
    Worksheet 7-2: Observing Pendulum Motion
    Worksheet 7-3: The Effects of Mass

## C. The Teacher's Manual

Accompanying the software and Activity Worksheets is a 21 page Teacher's Manual. The manual is divided into several sections.

**Part I** describes the factors that influenced the development of this software. In addition, our design goals for the students and teachers who will use this software are clearly stated. Finally, some of the more important educational benefits of computer simulation are presented.

**Part II** presents important information about the hardware and software required to run the simulation software. Explicit directions are also given for starting up and exiting the simulations.

**Part III** describes the documentation and support materials that accompany the software. The Activity Worksheet Series is introduced. Also, the three methods by which users can quickly introduce themselves to the software are described--the video introduction, the hands-on introduction, and the illustrated text.

**Part IV** suggests a number of instructional methodologies that teachers may want to follow while utilizing this courseware. Methods for using the courseware with learning disabled children are included. These recommendations are based on classroom field testing of the courseware. Recommendations for use with children in general are also found here.

**The Glossary** contains a complete description of all the terms introduced with this software package. For those unfamiliar with "mouse" terminology, a separate mouse glossary is provided. The larger glossary contains a description of all the terms associated with the Physical Science Laboratory.

## D. The Video Introduction

Although a video introduction was not one of the original project objectives, it was found to be a quick and "natural" way to introduce teachers--and eventually students--to the simulation environment. Videos also served the design team well in documenting features of the software as it was being developed.

There are three short videos (less than 15 minutes each) accompanying the software. The first of these, "Using A Mouse," introduces mouse terminology while at the same time demonstrating the unfamiliar word being described. This video is most suitable for people who have never used a mouse before.

The second video, "Touring The Lab," gives the potential user a detailed look at the features of the Physical Science Laboratory. Watching this video is the quickest way of learning how the software works.

The third video, "A Sneak Preview," provides a look at all the simulations. Teachers get an overview of the capabilities of each of the simulations - making it easier for them to evaluate the potential usefulness of the software and to familiarize themselves with its capabilities without having to sit down and use it.

## II. Field Test Evaluation

### A. Overview of the Process

The formative evaluation of the simulation software and the supporting materials was divided into two phases. During the first phase the software was tested in four school settings over a period of 2 months. The purpose of the Phase I activities was to determine whether the software was working in the manner intended. We were especially interested in learning what features were going to be troublesome for the target audience. We observed students using the software, and listened carefully to teachers' and students' comments.

During the second phase of the evaluation, the software was tested in three school settings over a period of 3 months. At this time the software was accompanied by all of the supporting materials including the Activity Worksheet Series and the video introductions. Meetings were held with teachers prior to installation to familiarize them with the new materials. Three evaluation instruments were prepared for this stage:

- Teacher Evaluation of Introductory Materials
- Teacher Evaluation of Experiment
- Student Evaluation of Experiment

During the second phase of the evaluation, students concentrated on completing the Activity Worksheets either with or without help from their teachers. Teachers worked with or observed students using the software and solving the problems on the Activity Worksheets. Teachers also maintained records of students' progress in completing the materials using a prepared checklist. We also observed and worked directly with students during this phase.

## B. The Evaluation Instruments

### 1) Teacher Evaluation of Introductory Materials

This evaluation instrument consists of a series of statements about the introductory materials. For each statement the respondent circles their level of agreement or disagreement on a scale of 1 to 5. A "1" indicates strong agreement; a "5" indicates strong disagreement. A "3" indicates that the respondent is essentially neutral on that topic. A section for written comments is provided at the end of each category of statements.

The categories of statements include:

- Part I: Video Introduction. Seven statements dealing with the three introductory videos.
- Part II: Hands-On Introduction. Four statements concerned specifically with Experiment 0, which is designed to familiarize users with the Physical Science Laboratory in a hands-on fashion.
- Part III: Written Documentation. Nine statements directed at the Teacher's Manual.

The form containing the actual statements regarding the teacher evaluation of introductory materials can be found in the Appendix of this report.

### 2) Teacher Evaluation of Experiment

This evaluation instrument also consists of a series of statements with which the respondent is asked to agree or disagree. It too is based on a scale of 1 to 5 where a "1" represents "strongly agree" and a "5" represents "strongly disagree." This same form is used to evaluate each experiment (simulation). To complete this evaluation form each teacher was instructed[2] as follows:

> Familiarize yourself with the Activity Worksheet Series, especially the introduction to each experiment. Work with or observe students using the courseware materials. Complete the form **Teacher Evaluation of Experiment** after you are thoroughly familiar with the materials and student reaction to a given experiment.

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[2] See the form entitled **Instructions for Teachers** in the Appendix of this report.

The evaluation form contains six categories of statements which are listed below. The numbers in parentheses indicate the number of statements associated with each category.

- Category A: General. (9)
- Category B: Learning To Use This Program. (6)
- Category C: Graphics. (3)
- Category D: Feedback (from the program to user). (8)
- Category E: Activity Worksheets. (5)
- Category F: Instruction. (3)

Several sources were consulted in developing this evaluation form. These include an in-depth discussion of computer simulation as an educational tool by Kistler (1988); a method for student evaluation of software by Callison and Haycock (1988); and an approach by Caffarella (1987).

Doll (1987) was used to provide specific microcomputer criteria and Derekek Blease's book "Evaluating Educational Software" (1986) provided a firm grounding in educational theory in developing the criteria for evaluation.

Some insights in what to look for while we were testing the software, and the problems we wanted to avoid in the final product were found in Perry (1986), and consequently some of his criteria found their way into the evaluation form.

Hoffmann's (1985) "Educational Software: Evaluation? No! Utility? Yes!" contains an assertion that supports our decisions about learner control of the software:

> "the important consideration is the user's perceived control which rests on the degree to which the user can manipulate the microcomputer environment in a purposive, exploratory fashion."

The need for teachers to watch students using the software being evaluated was an important consideration given by Test (1985), and influenced our recommendations for teachers doing the evaluating.

In the literature that we reviewed, we found no consensus as to what constitutes a definitive software evaluation. Instead, we drew from the literature in an eclectic fashion to establish questions about the factors we identified as being important: both to the teacher and the student--taking into consideration the special needs of the learning disabled student. The **Teacher Evaluation of Experiment** form can be found in the Appendix of this report.

### 3) Student Evaluation of Experiment

Students also had the opportunity to evaluate the software and its related materials. An evaluation form containing 20 statements was created. If the student agreed with the statement, they were instructed to circle the "Yes" response, if they did not agree with the statement, they were instructed to circle the "No" response. If the statement did not apply, they were instructed not to circle either response, and continue with the next question. The **Student Evaluation of Experiment** form can be found in the Appendix of this report.

## C. Summary of Evaluations

### 1) Participants

Three public schools in Chittenden County, Vermont, participated in the evaluation of the software and the accompanying materials:

1. Shelburne Middle School
   Chittenden South Supervisory School District
   Shelburne, Vermont 05482
   John Winton, Principal

2. Williston Central School
   Chittenden South Supervisory School District
   Williston, Vermont 05495
   Marion Stroud, Principal

3. Edmunds Middle School
   Burlington School District
   Burlington, Vermont 05401
   Reginald Cross, Principal

Six teachers participated in the evaluation process:

1. Linda Knickerbocker
   Special Educator, Grades 4-8
   Shelburne Middle School

2. M. Shawn Farley
   Regular Educator
   Special Education Assistant, Grades 4-8
   Shelburne Middle School

3. Ellen Farnsworth
   Special Education Tutor, Grades 4-8
   Shelburne Middle School

4. Scott Orselet
   Special Educator
   Williston Central School

5. Charles Wilson
   Computer Educator, K-8 Educational Program Development
   Williston Central School

6. John O. Mcguire
   Regular Educator/Special Educator
   Edmunds Middle School

## 2) Teacher Evaluation of Introductory Materials

Figure 1 summarizes the responses of the teachers to the introductory materials. Included are: the statement numbers and statements as they appear in the evaluation instrument; the number of teachers (n) responding to each statement; the MEAN response to each statement on a scale from 1 to 5 (where 1 = strongly agree and 5 = strongly disagree); and the standard deviation (SD) of the responses to each question.

## 3) Teacher Evaluation of Experiment

Figure 2 summarizes the responses of the teachers to each experiment. An overall summary[3] for each statement is shown in the column labeled ALL. For a given experiment the following items are included: the statement numbers and statements as they appear on the evaluation instruments; the number of teachers (n) responding to each statement; the MEAN response on a scale from 1 (strongly agree) to 5 (strongly disagree); and the Standard Deviation (SD) of the responses.

## 4) Student Evaluation of Experiment

Figure 3 summarizes the student responses to each experiment. The "number of respondents" to each experiment is shown across the top. These students successfully completed one or more of the Activity Worksheets for a given experiment. In most cases, these students had completed all of the Activity Worksheets for the given experiment before they completed the evaluation for that experiment.

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[3] The MEAN in the column labeled ALL is a weighted-average of the MEAN responses across all the experiments for a given statement. Each experiment MEAN is weighted by the number of teachers responding for that experiment.

The students in this group were drawn primarily from the special education populations of their respective schools, i.e., students having learning problems that require Individualized Educational Plans (IEPs). Occasionally, special education students were paired with regular education students and both their evaluations are included in this summary.

For each experiment, the "number responding" YES or NO to a given statement is shown. The "percent responding" YES or NO is computed by dividing the number responding to a given a statement by the number of respondents for that experiment. The percent responding may be less than 100 because students elected not to respond to some of the statements (which is appropriate for certain experiments), or circled both the YES and NO responses.

The column labeled TOTAL gives an overall picture of the responses across all of the experiments. The number responding YES or NO to a given statement in the TOTAL column is just the sum of the number responding YES or NO across all of the experiments. The percent responding is computed by dividing the number responding by the TOTAL number of respondents. The TOTAL column needs to be interpreted carefully in light of the particular evaluation statement to which it applies.

### 5) Supplementary Evaluation by a Regular Education Teacher and Her 5th Grade Class

Mary Woodruff, a 5th grade teacher at the Williston Central School, utilized **Experiment 5: Finding Seasonal Temperatures** to supplement a unit on weather and climate that she was teaching to her regular education class. Her evaluation of that experiment, and the evaluations of her students are shown in Figures 4 and 5, respectively.

## III. Dissemination

A major objective of Macro's proposal was the dissemination of the technology product that is the result of this project. No technology product will be seen and used by the special education community unless large numbers of teachers are made aware of its existence. Commercial publishing has always represented an important option. although we also considered distribution of the software as public domain "shareware".

During the final production of the materials, it became clear that the software and accompanying materials were too substantial to be a reasonable shareware product. When we demonstrated the software to publishers at TAM and CEC conferences, their enthusiasm for the product convinced us that it has good commercial potential.

Macro registered its copyright with the U.S. Copyright Office and began the process of letters, meetings and phone calls that constitutes good marketing. Mindscape, publisher of the product "Quest for Files" which resulted from an adaptation of instructional materials contract, was first to review the software and praised it highly. The company is experiencing a slump in sales and is currently unable to negotiate for new products to add to its existing catalog.

At the invitation of The Learning Company, a prize-winning software company, we sent it for review to Dr. David Rubin, Director of Development. He was very enthusiastic about the product's commercial potential as an educational software package; however, The Learning Company has just made a decision to acquire only those software programs that have home market potential as well as educational potential and this software is definitely designed for the classroom. Dr. Rubin suggested that we send it to Sunburst Communications.

Project Director Garrett Hughes spoke with the Director of Development for Focus Media at the National Educational Computing Conference and that company requested the opportunity to review the product as well.

At this writing, we are waiting to hear from Sunburst and Focus Media. Both companies have had the materials for a short time and normal evaluation by a software company for potential publications takes from 2 to 6 months.

# Chapter III

# Project Methodology

# Chapter III. Project Methodology

## I. Phase 1: Material Development

### A. Organization of the Design Team

A design team consisting of Macro staff and four teachers from three local school districts was organized to formalize the design of the science simulation software.

Two of the teachers who served on this design team are special education teachers with responsibility for the special education programs in their own schools. The other two teachers are computer coordinators: one serving the needs of an entire school district, and the other assigned to a single elementary school while working with a district-wide technology committee.

Teachers on design team included:

Allen Currier
Computer Coordinator
Burlington School District
Burlington, Vermont

Linda Knickerbocker
Special Educator
Shelburne Middle School
Chittenden South Supervisory School District
Shelburne, Vermont

Scott Orselet
Special Educator
Williston Central School
Chittenden South Supervisory School District
Williston, Vermont

Charles Wilson
Computer Coordinator
Williston Central School
Chittenden South Supervisory School District
Williston, Vermont

### B. Creation of Storyboards

The design team held five 3-hour evening meetings over a period of 4 months. The goal of these meetings was to specify, as clearly as possible, the design of the science simulations.

After reviewing the criteria established in the proposal, and analyzing the needs of the target group, the design team decided to emphasize the following goals in their design efforts: they would design the simulations so that students could learn how to

- Do basic measurements
- Use these basic measurement skills to solve problems in a physical science context

The design team then began fleshing out the simulations. These efforts were facilitated by the use of two paper forms (see Appendix). One of these forms was used to create storyboards, and the other was used for writing out the functional specifications of equipment and objects that would appear in a given simulation. The drawings and functional specifications were presented and discussed by the design team members at their meetings. After the third meeting of the design team, the programming staff and graphic artists at Macro were able to create working prototypes from the preliminary specifications. These gave the design team a better "look and feel" for how the simulations would actually behave.

During this phase, members of the design team reviewed the current literature and reviewed existing science simulations in the realm of the physical sciences. Only one piece of published software came close to the design goals of the Physical Science Laboratory. This was a set of chemistry simulations known as "Chem Lab," published by Simon & Schuster.

Chem Lab taught us several valuable lessons in what not to do when designing science simulations. The design team decided not to use the keyboard, at all, to enter instructions: the commands have to be learned and entered - a difficult set of skills to acquire. In addition, the keyboard severely limits the user's freedom of motion in manipulating objects on the screen. The mouse was selected as the sole input device.

As a result of trying to decipher the relatively complicated user's manual for Chem Lab, the design team decided to produce one or more short, informal videos that would introduce the simulation software and demonstrate the basic commands used to control it. As a result, a teacher could use a video to review the software or learn to use the software in a relatively short period of time - independent of the availability of the actual hardware or software itself.

At the end of the 4-month design period, the design team had put together a series of storyboards and functional specifications that formed the framework for the programming effort. Fourteen simulations were proposed. These included the following working numbers and titles:

0. The Lab
1. Finding Elapsed Time
2. Finding Length And Width
3. Finding Area
4. Finding Distance Using A Map
5. Finding Seasonal Temperatures
6. Finding Refrigerator Temperatures
7. Finding Oven And Burner Temperatures
8. Finding Mass With A Beam Balance
9. Finding Liquid Volume
10. Pendulum
11. Inclined Plane
12. Using A Lever
13. Phase Change: Water

The first of these, "The Lab," would be used to introduce the students to the simulated laboratory environment in which they would find themselves when working with any of the simulations.

The next nine simulations were designed to help students learn basic measurement skills in a variety of experimental, problem-solving environments. Each of these simulations would display a large instrument with an analog scale. A small, moveable "icon" instrument would control the reading on the large scale. Measurements would be visible on the analog scale as well as in digital format in the "value bar" associated with the measurement instrument. Measurements would also be audible through the use of voice synthesis.

The final four simulations were designed to allow the student to apply his or her measurement skills to solve problems in a more typical physical science laboratory environment.

One of the unique features of this software was to be the flexibility in the way it could be used by individual teachers. The software itself was not designed to provide instruction, but to establish learning environments. The teacher would use these environments for instructional purposes by utilizing Activity Worksheets. These worksheets would guide or structure the students interaction with the learning environment to produce the desired educational objectives. Preliminary educational objectives were formulated for each of the simulations designed.

For learning disabled students, the teacher and student could work together to solve the problems on the worksheets. The worksheets were to be written for a sixth-grade reading level, so that students could work by themselves or in pairs where that was deemed feasible by the teacher. The intent has always been for, the teacher to maintain control of the instructional process.

### C. Writing and Debugging the Programs

In the scheduled time available, the design team decided to concentrate their efforts on implementing those simulations which would provide the maximum benefit for the learning disabled students. These included the simulations which stressed basic measurements done in practical, familiar environments.

Once the basic laboratory environment was created (Experiment 0), it was found to take about 5 weeks of programming effort to write and debug each one of the simulations. Within the scheduled time available, it was possible to create Experiments 1 through 6. Experiment 7 was added to demonstrate the possibilities for a more sophisticated experiment, once the basic measurement skills had been learned by the student.

## II. Phase 2: Field Testing

Field testing was carried out in two phases. The first phase lasted approximately 2 months; four different schools were involved in the testing process. An Apple II/GS computer was supplied to each of the schools in turn for about 2 weeks duration. During this time Macro staff visited the schools and observed the software in use. Preliminary versions of the Activity Worksheets were supplied for use during this time. Macro staff consulted frequently with the teachers and students who were using the simulation software and the Activity Worksheets. Debugging activities and improvements to the existing software were carried out on a daily basis.

The second phase of the testing period lasted approximately 3 months. Three public schools in Chittenden County, Vermont, simultaneously participated in this phase. The names and addresses of these schools have been given previously in the section titled "Participants." During the second phase of the field testing all schools received the final versions of the simulation software, teacher's manual, video introduction, and evaluation instruments. Students using the materials were tracked by their teacher(s) using a prepared checklist. When a student had completed all or most of the Activity Worksheets associated with a given experiment, they were asked to fill out an evaluation questionnaire for that experiment. These questionnaires have been described in detail above, along with a summary of both the teachers' and students' evaluations.

In each of the three schools participating in the second phase, teachers sat with the special education students at the computer as they worked through the Activity Worksheets. In most cases, two students worked at a computer at the same time. The teacher would answer questions, if asked, about the nature of the assignment. For the most part the students took their instructions from the Activity Worksheets.

## Figure 1(1)

## SUMMARY OF EVALUATIONS
## TEACHER EVALUATION OF INTRODUCTORY MATERIALS

n = Number Of Teachers Responding To Each Statement

Mean = Average Of Responses On A Scale From 1 To 5
where 1 = Strongly Agree, 5 = Strongly Disagree

SD = Standard Deviation

| No. | Statement | n | Mean | SD |
|---|---|---|---|---|
| 01. | The Video "Using A Mouse provides good instruction in learning how to use a mouse. | 6 | 2.2 | 1.2 |
| 02. | I would recommend the video "Using A Mouse" to another teacher for use as an instructional tool. | 6 | 2.8 | 1.0 |
| 03. | I would use the video "Using A Mouse to instruct students in how to use a mouse. | 6 | 3.2 | 1.3 |
| 04. | The video "Touring the Lab" provides a good overview of the basic features of the Physical Science Laboratory. | 6 | 2.7 | 0.5 |
| 05. | I could describe the basic features of the lab to another teacher after viewing the video "Touring the Lab." | 6 | 2.5 | 3.3 |
| 06. | I would use the video "Touring the Lab" to instruct students in the basic features of the Physical Science Laboratory. | 6 | 3.3 | 1.2 |
| 07. | Having a person watch the video "A Sneak Preview" is a good way to introduce them to the simulated environments in the Physical Science Laboratory. | 6 | 1.7 | 0.5 |

**Figure 1(2)**

| No. | Statement | n | Mean | SD |
|---|---|---|---|---|
| 08. | The instructions in the Teacher's Manual for getting started with the hands-on materials are clear. | 6 | 1.2 | 0.4 |
| 09. | Starting up Experiment 0 did not present any significant problems. | 6 | 1.2 | 0.4 |
| 10. | Using the HELP feature is a convenient way to discover the names of objects and places in the Physical Science Laboratory. | 6 | 1.5 | 0.8 |
| 11. | Working through the Activity Worksheets for Experiment 0 is a good way to familiarize yourself with the lab's features. | 6 | 2.7 | 1.2 |
| 12. | It is easy to find what you are looking for in the Teacher's Manual. | 6 | 1.3 | 0.5 |
| 13. | The software's statement of purpose is clearly presented in the Teacher's Manual. | 6 | 1.5 | 0.5 |
| 14. | The software's intended audience is clearly presented. | 6 | 1.7 | 0.5 |
| 15. | The software's special features for the learning impaired are clearly presented. | 6 | 2.0 | 0.9 |
| 16. | The software's intended goals for the student are clearly presented. | 6 | 1.7 | 1.2 |
| 17. | The software's goals for the teacher are clearly presented. | 6 | 2.0 | 1.1 |

**Figure 1(3)**

| No. | Statement | n | Mean | SD |
|---|---|---|---|---|
| 18. | The software's hardware and software requirements are made clear. | 6 | 1.3 | 0.5 |
| 19. | The glossary of mouse terminology is clearly presented. | 6 | 1.0 | 0.0 |
| 20. | The glossary of Physical Science Laboratory terminology is clearly presented. | 6 | 1.0 | 0.0 |

FIGURE 1

## SUMMARY OF EVALUATIONS
## TEACHER EVALUATION OF INTRODUCTORY MATERIALS

n = Number Of Teachers Responding To Each Statement

Mean = Average of Responses On A Scale From 1 To 5
where 1 = Strongly Agree, 5 = Strongly Disagree

SD = Standard Deviation

| No. | Statement | n | MEAN | SD |
|---|---|---|---|---|
| 01. | The Video "Using A Mouse provides good instruction in learning how to to use a mouse. | 6 | 2.2 | 1.2 |
| 02. | I would recommend the video "Using A Mouse" to another teacher for use as an instructional tool. | 6 | 2.8 | 1.0 |
| 03. | I would use the video "Using A Mouse to instruct students in how to use a mouse. | 6 | 3.2 | 1.3 |
| 04. | The video "Touring the Lab" provides a good overview of the basic features of the Physical Science Laboratory | 6 | 2.7 | 0.5 |
| 05. | I could describe the basic features of the lab to another teacher after viewing the video "Touring the Lab" | 6 | 2.5 | 0.5 |
| 06. | I would use the video "Touring the Lab" to instruct students in the basic features of the Physical Science Laboratory. | 6 | 3.3 | 1.2 |
| 07. | Having a person watch the video "A Sneak Preview" is a good way to introduce them to the simulated environments in the Physical Science Laboratory. | 6 | 1.7 | 0.5 |
| 08. | The instructions in the Teacher's Manual for getting started with the hands-on materials are clear. | 6 | 1.2 | 0.4 |
| 09. | Starting up Experiment 0 did not present any significant problems. | 6 | 1.2 | 0.4 |

Figure 1 (continued)

| | | | | |
|---|---|---|---|---|
| 10. | Using the HELP feature is a convenient way to discover the names of objects and places in the Physical Science Laboratory. | 6 | 1.5 | 0.8 |
| 11. | Working through the Activity Worksheets for Experiment 0 is a good way to familiarize yourself with the lab's features. | 6 | 2.7 | 1.2 |
| 12. | It is easy to find what you are looking for in the Teacher's manual. | 6 | 1.3 | 0.5 |
| 13. | The software's statement of purpose is clearly presented in the Teachers Manual. | 6 | 1.5 | 0.5 |
| 14. | The software's intended audience is clearly presented. | 6 | 1.7 | 0.5 |
| 15. | The software's special features for the learning impaired are clearly presented. | 6 | 2.0 | 0.9 |
| 16. | The software's intended goals for the student are clearly presented. | 6 | 1.7 | 1.2 |
| 17. | The software's intended goals for the teacher are clearly presented. | 6 | 2.0 | 1.1 |
| 18. | The software's hardware and software requirements are made clear. | 6 | 1.3 | 0.5 |
| 19. | The glossary of mouse terminology is clearly presented. | 6 | 1.0 | 0.0 |
| 20. | The glossary of Physical Science Laboratory terminology is clearly presented. | 6 | 1.0 | 0.0 |

Figure 2(1)

## SUMMARY OF EVALUATIONS: TEACHER EVALUATION OF EXPERIMENT

n = number of teachers responding
Mean = average on scale of 1 to 5
1=strongly agree, 5=strongly disagree
SD = Standard Deviation

| | | EXPERIMENT NUMBER | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Statement | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 10 | ALL | |
| 01. | The Activity Worksheet Series Introduction to this experiment clearly presents the educational objectives of this simulation. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | n |
| | | 2.0 | 1.4 | 1.3 | 1.0 | 2.0 | 2.0 | 1.0 | 1.0 | 1.5 | MEAN |
| | | 0.7 | 0.5 | 0.5 | 0.0 | - | 0.0 | - | 0.0 | | SD |
| 02. | The important features of this experiment are thoroughly explained in the Activity Worksheet Series Introduction. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 2.0 | 1.4 | 1.0 | 1.0 | 2.0 | 2.0 | 1 | 1.0 | 1.4 | |
| | | 0.7 | 0.5 | 0.0 | 0.0 | - | 0.0 | - | 0.0 | | |
| 03. | The concepts presented in this computer simulation are well-suited for learning with the help of a computer. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 1.0 | 1.2 | 3.8 | 1.7 | 1 | 1.5 | 1 | 1.0 | 1.7 | |
| | | 0.0 | 0.4 | 0.5 | 0.6 | - | 0.7 | - | 0.0 | | |
| 04. | Use of this computer simulation aloing with the Activity Worksheets will accomplish the educational objectives stated in the Activity Worksheet Series Information. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 2.2 | 1.0 | 1.3 | 1.3 | 1 | 2.0 | 1 | 1.5 | 1.5 | |
| | | 0.8 | 0.0 | 0.5 | 0.6 | - | 1.4 | - | 0.7 | | |
| | | | | | | | | | | | |
| 05. | This computer simulation provides a needed learning tool for all students. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 1.8 | 2.0 | 3.5 | 2.8 | 1 | 2.0 | 1 | 1.0 | 2.1 | |
| | | 0.8 | 1.0 | 1.0 | 1.6 | - | 0.0 | - | 0.0 | | |

**Figure 2(2)**

n = number of teachers responding
Mean = average on scale of 1 to 5
1=strongly agree, 5=strongly disagree
SD = Standard Deviation

| | | EXPERIMENT NUMBER | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 10 | ALL | |
| No. | Statement | | | | | | | | | | |
| 06. | This computer simulation provides a needed learning tool for the special educational student when used in a special education instructional environment. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | n |
| | | 1.0 | 2.2 | 3.5 | 3.3 | 1 | 1.0 | 1 | 2.3 | 2.1 | MEAN |
| | | 0.0 | 1.1 | 1.0 | 2.1 | - | 0.0 | - | 1.8 | | SD |
| 07. | This computer simulation is particularly well-situated to the learning needs of the mainstreamed special education student. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 2.4 | 1.6 | 3.5 | 2.7 | 1 | 1.0 | 1 | 2.5 | 2.2 | |
| | | 1.3 | 0.5 | 1.0 | 1.5 | - | 0.0 | - | 2.1 | | |
| 08. | This computer simulation provides a valuable teaching tool for teachers to use in an instructional environment. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 1.4 | 2.0 | 4.0 | 2.3 | 1 | 1.5 | 1 | 1.5 | 2.1 | |
| | | 0.5 | 1.0 | 1.4 | 1.2 | - | 0.7 | - | 0.7 | | |
| 09. | This computer simulation provides a valuable teaching tool for teachers to use in a special education instructional environment. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 1.4 | 2.2 | 3.5 | 2.7 | 1 | 1.0 | 1 | 2.0 | 2.1 | |
| | | 0.5 | 1.1 | 1.0 | 1.5 | - | 0.0 | - | 1.4 | | |
| 10. | A teacher with little or no computer experience could operate this program. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 2.8 | 2.6 | 2.8 | 3.0 | 2 | 1.5 | 2 | 1.5 | 2.5 | |
| | | 0.8 | 1.1 | 0.5 | 1.0 | - | 0.7 | - | 0.7 | | |

**Figure 2(3)**

n = number of teachers responding
Mean = average on scale of 1 to 5
1=strongly agree, 5=strongly disagree
SD = Standard Deviation

**EXPERIMENT NUMBER**

| No. | Statement | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 10 | ALL | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11. | Based on your observations, students with little or no computer experience could operate this program. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | n |
| | | 2.2 | 1.8 | 2.3 | 2.3 | 2 | 1.5 | 2 | 1.0 | 2.0 | MEAN |
| | | 0.8 | 1.1 | 1.0 | 1.2 | - | 0.7 | - | 0.0 | | SD |
| 12. | The time required to learn how to operate just this program is less than 15 minutes. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 2.2 | 2.2 | 2.3 | 2.3 | 2 | 1.5 | 2 | 1.5 | 2.1 | |
| | | 0.8 | 0.8 | 1.0 | 1.2 | - | 0.7 | - | 0.7 | | |
| 13. | Students not classified as special education students had little or no difficulty using the mouse to control simulation. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 1.8 | 1.8 | 1.8 | 1.7 | 1 | 1.5 | 1 | 1.5 | 1.7 | |
| | | 0.4 | 0.4 | 0.5 | 0.6 | - | 0.7 | - | 0.7 | | |
| 14. | Students classified as special education had little or no difficulty using the mouse to control this simulation. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 2.0 | 1.8 | 1.8 | 1.7 | 2 | 2.0 | 2 | 2.0 | 1.9 | |
| | | 0.0 | 0.4 | 0.5 | 0.6 | - | 0.0 | - | 0.0 | | |
| 15. | The measurement instruments in this program were easy to use. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 2.4 | 1.0 | 3.0 | 2.3 | 2 | 2.0 | 2 | 1.0 | 2.0 | |
| | | 1.1 | 0.0 | 0.8 | 1.2 | - | 0.0 | - | 0.0 | | |

Figure 2(4)

n = number of teachers responding
Mean = average on scale of 1 to 5
1=strongly agree, 5=strongly disagree
SD = Standard Deviation

EXPERIMENT NUMBER

| No. | Statement | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 10 | ALL | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 16. | The simulation's graphics, are appropriate for the intended student audience. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | n |
| | | 1.2 | 1.4 | 1.5 | 1.3 | 2 | 1.5 | 1 | 1.5 | 1.4 | MEAN |
| | | 0.4 | 0.5 | 0.6 | 0.6 | - | 0.7 | - | 0.7 | | SD |
| 17. | The simulation's graphics are appropriate for the task at hand. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 1.4 | 1.4 | 2.5 | 1.0 | 2 | 1.5 | 1 | 1.5 | 1.6 | |
| | | 0.5 | 0.5 | 0.6 | 0.0 | - | 0.7 | - | 0.7 | | |
| 18. | The simulation's graphics help focus the student's attention on the task at hand. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 1.4 | 1.6 | 1.8 | 1.7 | 2 | 1.0 | 1 | 1.0 | 1.5 | |
| | | 0.9 | 0.9 | 1.0 | 0.6 | - | 0.0 | - | 0.0 | | |
| 19. | Students can understand the numeric measurements when they are displayed by the units bars | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 1.4 | 1.4 | 1.0 | 1.0 | 1 | 2.0 | 1 | 1.5 | 1.3 | |
| | | 0.5 | 0.5 | 0.0 | 0.0 | - | 0.0 | - | 0.7 | | |
| 20. | Students can understand the numeric measurements when they are spoken by the computer. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 1.4 | 1.2 | 1.3 | 1.0 | 1 | 1.0 | 1 | 1.0 | 1.2 | |
| | | 0.5 | 0.4 | 0.5 | 0.0 | - | 0.0 | - | 0.0 | | |

**Figure 2(5)**

n = number of teachers responding
Mean = average on scale of 1 to 5
1=strongly agree, 5=strongly disagree
SD = Standard Deviation

EXPERIMENT NUMBER

| No. | Statement | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 10 | ALL | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 21. | The capability to hide or display numeric measurements enhances the instructional use of this program. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | n |
| | | 1.2 | 1.2 | 1.3 | 1.3 | 1 | 1.0 | 1 | 1.0 | 1.2 | MEAN |
| | | 0.4 | 0.4 | 0.5 | 0.6 | - | 0.0 | - | 0.0 | | SD |
| 22. | The capability to have the computer speak the numeric measurements enhances the instructional use of this program. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 1.0 | 1.0 | 1.0 | 1.0 | 1 | 1.0 | 1 | 1.0 | 1.0 | |
| | | 0.0 | 0.0 | 0.0 | 0.0 | - | 0.0 | - | 0.0 | | |
| 23. | Students can understand the HELP windows whyie using the HELP mode. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 1.4 | 1.6 | 1.3 | 1.0 | 1 | 2.0 | 1 | 1.5 | 1.4 | |
| | | 0.5 | 0.9 | 0.5 | 0.0 | - | 1.4 | - | 0.7 | | |
| 24. | Students find the HELP messages useful. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 1.4 | 1.4 | 1.0 | 1.0 | 1 | 2.0 | 1 | 1.5 | 1.3 | |
| | | 0.9 | 0.9 | 0.0 | 0.0 | - | 1.4 | - | 0.7 | | |
| 25. | Students can understand the HELP messages when they are spoken by the computer. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 1.6 | 1.4 | 1.3 | 1.0 | 1 | 1.5 | 1 | 1.0 | 1.3 | |
| | | 0.9 | 0.5 | 0.5 | 0.0 | - | 0.7 | - | 0.0 | | |

**Figure 2(6)**

n = number of teachers responding
Mean = average on scale of 1 to 5
1=strongly agree, 5=strongly disagree
SD = Standard Deviation

**EXPERIMENT NUMBER**

| No. | Statement | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 10 | ALL | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 26. | The absence of value judgements (by the program to the student) actually enhances the instructional environment created by this program. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | n |
| | | 1.8 | 2.0 | 2.0 | 2.3 | 1 | 1.5 | 1 | 1.5 | 1.8 | MEAN |
| | | 1.1 | 1.0 | 1.2 | 1.2 | - | 0.7 | - | 0.0 | | SD |
| 27. | Students have little difficulty understanding the written instructions on the Activity Worksheets. | 5 | 5 | 4 | 3 | 1 | 1 | 1 | 2 | 22 | |
| | | 3.0 | 2.8 | 2.8 | 3.0 | 2 | 2.0 | 2 | 2.0 | 2.7 | |
| | | 0.7 | 0.8 | 1.0 | 1.0 | - | - | - | 0.0 | | |
| 28. | Students are able to complete the Activity Worksheets with little or no help from the teacher. | 4 | 5 | 4 | 3 | 1 | 1 | 1 | 2 | 21 | |
| | | 2.5 | 2.2 | 2.3 | 2.0 | 2 | 2.0 | 2 | 2.0 | 2.2 | |
| | | 0.6 | 0.8 | 0.5 | 0.0 | - | - | - | 0.0 | | |
| 29. | The time required to complete any one of the Activity Worksheets does not exceed the student's attention span. | 4 | 5 | 4 | 3 | 1 | 1 | 1 | 2 | 21 | |
| | | 2.5 | 1.0 | 2.0 | 2.7 | 2 | 2.0 | 2 | 1.5 | 1.9 | |
| | | 0.6 | 0.0 | 0.0 | 0.6 | - | - | - | 0.7 | | |
| 30. | The Activity Worksheet problems are well correlated with the stated objectives for this simulation. | 4 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 22 | |
| | | 1.0 | 1.0 | 1.0 | 1.7 | 1 | 1.5 | 1 | 1.0 | 1.1 | |
| | | 0.0 | 0.0 | 0.0 | 0.6 | - | 0.7 | - | 0.0 | | |

**Figure 2(7)**

n = number of teachers responding
Mean = average on scale of 1 to 5
1=strongly agree, 5=strongly disagree
SD = Standard Deviation

EXPERIMENT NUMBER

| No. | Statement | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 10 | ALL | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 31. | There is a need for more of this type of software, which allows the teacher to design the problems for the student to solve. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | n |
| | | 2.0 | 2.0 | 2.5 | 2.3 | 1 | 1.0 | 1 | 1.0 | 1.9 | MEAN |
| | | 1.0 | 1.0 | 1.0 | 1.2 | – | 0.7 | – | 0.0 | | SD |
| 32. | Students are interested in the topic addressed by this simulation. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 1 | 22 | |
| | | 2.8 | 1.6 | 2.3 | 2.7 | 1 | 1.0 | 1 | 2.0 | 2.1 | |
| | | 0.4 | 0.5 | 0.5 | 0.6 | – | 0.0 | – | 0.0 | | |
| 33. | Students would like to sovle other problems in physical science using simulation. | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 2 | 12 | |
| | | 2.5 | 1.0 | 1.0 | 1.0 | 1 | 1.0 | 1 | 1.0 | 1.3 | |
| | | 0.7 | 0.0 | 0.0 | 0.0 | – | 0.0 | – | 0.0 | | |
| 34. | The computer simulation along with the problems posed by the Activity Worksheets provide an excellent learning environment for students. | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 2 | 23 | |
| | | 2.4 | 2.0 | 3.1 | 2.0 | 1 | 1.0 | 1 | 1.0 | 2.0 | |
| | | 0.9 | 1.0 | 1.4 | 1.0 | – | 0.0 | – | 0.0 | | |

## Figure 3(1)

## SUMMARY OF EVALUATIONS: STUDENT EVALUATION OF EXPERIMENT

EXPERIMENT NUMBER

| | | 0 | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 10 | | TOTAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of Respondents | | 15 | | 5 | | 4 | | 3 | | 3 | | 3 | | 6 | | 6 | | 45 | | |
| Response | | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | |
| No. | Statement | | | | | | | | | | | | | | | | | | | |
| 01. | I watched the video "Using A Mouse." | 9 | 6 | 5 | 0 | 4 | 0 | 3 | 0 | 3 | 0 | 0 | 3 | 3 | 3 | 2 | 3 | 29 | 33 | Number Responding |
| | | 60 | 40 | 100 | 0 | 100 | 0 | 100 | 0 | 100 | 0 | 0 | 100 | 50 | 50 | 33 | 50 | 64 | 15 | Percent Responding |
| 02. | I watched the video "Touring The Lab." | 9 | 6 | 5 | 0 | 4 | 0 | 3 | 0 | 3 | 0 | 0 | 3 | 3 | 3 | 2 | 3 | 29 | 33 | |
| | | 60 | 40 | 100 | 0 | 100 | 0 | 100 | 0 | 100 | 0 | 0 | 100 | 50 | 50 | 33 | 50 | 64 | 15 | |
| 03. | One of my teachers explained to me how to run this experiment before I began doing it myself. | 4 | 11 | 3 | 2 | 1 | 3 | 1 | 2 | 2 | 1 | 1 | 2 | 3 | 3 | 2 | 4 | 17 | 28 | |
| | | 27 | 73 | 60 | 40 | 25 | 75 | 33 | 67 | 67 | 33 | 33 | 67 | 50 | 50 | 33 | 67 | 38 | 62 | |
| 04. | This was the first time I used a mouse to move things around on the computer screen. | 2 | 13 | 0 | 5 | 0 | 4 | 0 | 3 | 0 | 3 | 0 | 3 | 0 | 6 | 0 | 6 | 2 | 43 | |
| | | 13 | 87 | 0 | 100 | 0 | 100 | 0 | 100 | 0 | 100 | 0 | 100 | 0 | 100 | 0 | 100 | 4 | 96 | |
| 05. | I liked the way the objects were drawn on the computer screen. | 14 | 1 | 4 | 1 | 4 | 0 | 3 | 0 | 3 | 0 | 3 | 0 | 6 | 0 | 6 | 0 | 43 | 2 | |
| | | 93 | 7 | 80 | 20 | 100 | 0 | 100 | 0 | 100 | 0 | 100 | 0 | 100 | 0 | 100 | 0 | 96 | 4 | |

**Figure 3(2)**

EXPERIMENT NUMBER

| | 0 | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 10 | | TOTAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of Respondents | 15 | | 5 | | 4 | | 3 | | 3 | | 3 | | 6 | | 6 | | 45 | | |
| Response | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | |
| No. Statement | | | | | | | | | | | | | | | | | | | |
| 06. Using the ruler instrument was easy. | 11 | 2 | 2 | 0 | 3 | 1 | 3 | 0 | 3 | 0 | 2 | 1 | 4 | 0 | 3 | 1 | 31 | 5 | Number Responding |
| | 73 | 13 | 40 | 0 | 75 | 25 | 100 | 0 | 100 | 0 | 67 | 33 | 67 | 0 | 50 | 17 | 69 | 11 | Percent Responding |
| 07. Using the thermometer instrument was easy. | 11 | 1 | 2 | 0 | 2 | 0 | 2 | 0 | 2 | 0 | 3 | 0 | 5 | 0 | 4 | 0 | 31 | 1 | |
| | 73 | 7 | 40 | 0 | 50 | 0 | 67 | 0 | 67 | 0 | 100 | 0 | 83 | 0 | 67 | 0 | 69 | 2 | |
| 08. Using the scale (beam balance) was easy. | 3 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 6 | 0 | 12 | 2 | |
| | 20 | 7 | 0 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 67 | 0 | 17 | 0 | 100 | 0 | 27 | 4 | |
| 09. Using the car was easy. | 1 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 1 | 0 | 1 | 0 | 2 | 3 | 8 | |
| | 7 | 13 | 0 | 20 | 0 | 0 | 0 | 0 | 67 | 33 | 0 | 33 | 0 | 17 | 0 | 33 | 7 | 18 | |
| 10. I understood the computer when it spoke the numbers. | 11 | 4 | 3 | 60 | 3 | 1 | 1 | 2 | 1 | 2 | 2 | 1 | 6 | 0 | 4 | 1 | 31 | 13 | |
| | 73 | 27 | 2 | 40 | 75 | 25 | 33 | 67 | 33 | 67 | 67 | 33 | 100 | 0 | 67 | 17 | 69 | 29 | |
| 11. I learned how to get help from the computer while doing the experiment. | 14 | 1 | 5 | 0 | 3 | 1 | 3 | 0 | 3 | 0 | 3 | 0 | 6 | 0 | 5 | 0 | 42 | 2 | |
| | 93 | 7 | 100 | 0 | 75 | 25 | 100 | 0 | 100 | 0 | 100 | 0 | 100 | 0 | 83 | 0 | 93 | 4 | |

Figure 3(3)

EXPERIMENT NUMBER

| | | 0 | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 10 | | TOTAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of Respondents | | 15 | | 5 | | 4 | | 3 | | 3 | | 3 | | 6 | | 6 | | 45 | | |
| Response | | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | |
| No. | Statement | | | | | | | | | | | | | | | | | | | |
| 12. | I was able to do most of this experiment by myself. | 10 | 4 | 2 | 3 | 3 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 4 | 2 | 3 | 3 | 28 | 16 | Number Responding |
| | | 67 | 27 | 40 | 60 | 75 | 25 | 67 | 33 | 67 | 33 | 67 | 33 | 67 | 33 | 50 | 50 | 62 | 2 | Percent Responding |
| 13. | I felt like I had control over the experiement. | 9 | 4 | 3 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 6 | 0 | 5 | 1 | 30 | 13 | |
| | | 60 | 27 | 60 | 40 | 50 | 50 | 67 | 33 | 33 | 67 | 67 | 33 | 100 | 0 | 83 | 17 | 67 | 29 | |
| 14. | I understood the instructions on the Activity Worksheets. | 13 | 2 | 3 | 2 | 4 | 0 | 3 | 0 | 3 | 0 | 3 | 0 | 6 | 0 | 5 | 1 | 40 | 5 | |
| | | 87 | 13 | 60 | 40 | 100 | 0 | 100 | 0 | 100 | 0 | 100 | 0 | 100 | 0 | 83 | 17 | 89 | 11 | |
| 15. | I liked this program better than programs that tell me if I'm right or wrong. | 11 | 3 | 5 | 0 | 3 | 1 | 3 | 0 | 3 | 0 | 2 | 1 | 5 | 0 | 5 | 1 | 37 | 6 | |
| | | 73 | 20 | 100 | 0 | 75 | 25 | 100 | 0 | 100 | 0 | 67 | 33 | 83 | 0 | 83 | 17 | 82 | 13 | |
| 16. | I thought the experiment was interesting. | 8 | 5 | 5 | 0 | 2 | 2 | 3 | 0 | 3 | 0 | 2 | 1 | 6 | 0 | 5 | 1 | 34 | 9 | |
| | | 53 | 33 | 100 | 0 | 50 | 50 | 100 | 0 | 100 | 0 | 67 | 33 | 100 | 0 | 83 | 17 | 16 | 20 | |

Figure 3(4)

EXPERIMENT NUMBER

|  |  | 0 |  | 1 |  | 2 |  | 3 |  | 4 |  | 5 |  | 6 |  | 10 |  | TOTAL |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of Respondents |  | 15 |  | 5 |  | 4 |  | 3 |  | 3 |  | 3 |  | 6 |  | 6 |  | 45 |  |  |
| Response |  | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |  |
| No. | Statement |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 17. | The questions on the activity worksheets were too hard for me. | 1 | 14 | 0 | 5 | 0 | 4 | 0 | 3 | 0 | 3 | 0 | 3 | 1 | 5 | 0 | 6 | 2 | 43 | Number Responding |
|  |  | 7 | 93 | 0 | 100 | 0 | 100 | 0 | 100 | 0 | 100 | 0 | 100 | 17 | 83 | 0 | 100 | 4 | 96 | Percent Responding |
| 18. | Using this program is a good way to learn about this subject. | 14 | 1 | 4 | 1 | 2 | 2 | 3 | 0 | 3 | 0 | 2 | 1 | 6 | 0 | 6 | 0 | 40 | 5 |  |
|  |  | 93 | 7 | 80 | 20 | 50 | 50 | 100 | 0 | 100 | 0 | 67 | 33 | 100 | 0 | 100 | 0 | 89 | 11 |  |
| 19. | I liked using this program better than using an actual science lab. | 7 | 7 | 2 | 3 | 2 | 2 | 3 | 0 | 2 | 1 | 2 | 1 | 5 | 1 | 3 | 3 | 26 | 18 |  |
|  |  | 47 | 47 | 40 | 60 | 50 | 50 | 100 | 0 | 67 | 33 | 67 | 33 | 83 | 17 | 50 | 50 | 58 | 40 |  |
| 20. | I'd like to learn more science using programs like this one. | 10 | 3 | 4 | 1 | 3 | 1 | 3 | 0 | 3 | 0 | 0 | 2 | 6 | 0 | 5 | 1 | 34 | 8 |  |
|  |  | 67 | 20 | 80 | 20 | 75 | 25 | 100 | 0 | 100 | 0 | 0 | 67 | 100 | 0 | 83 | 17 | 76 | 18 |  |

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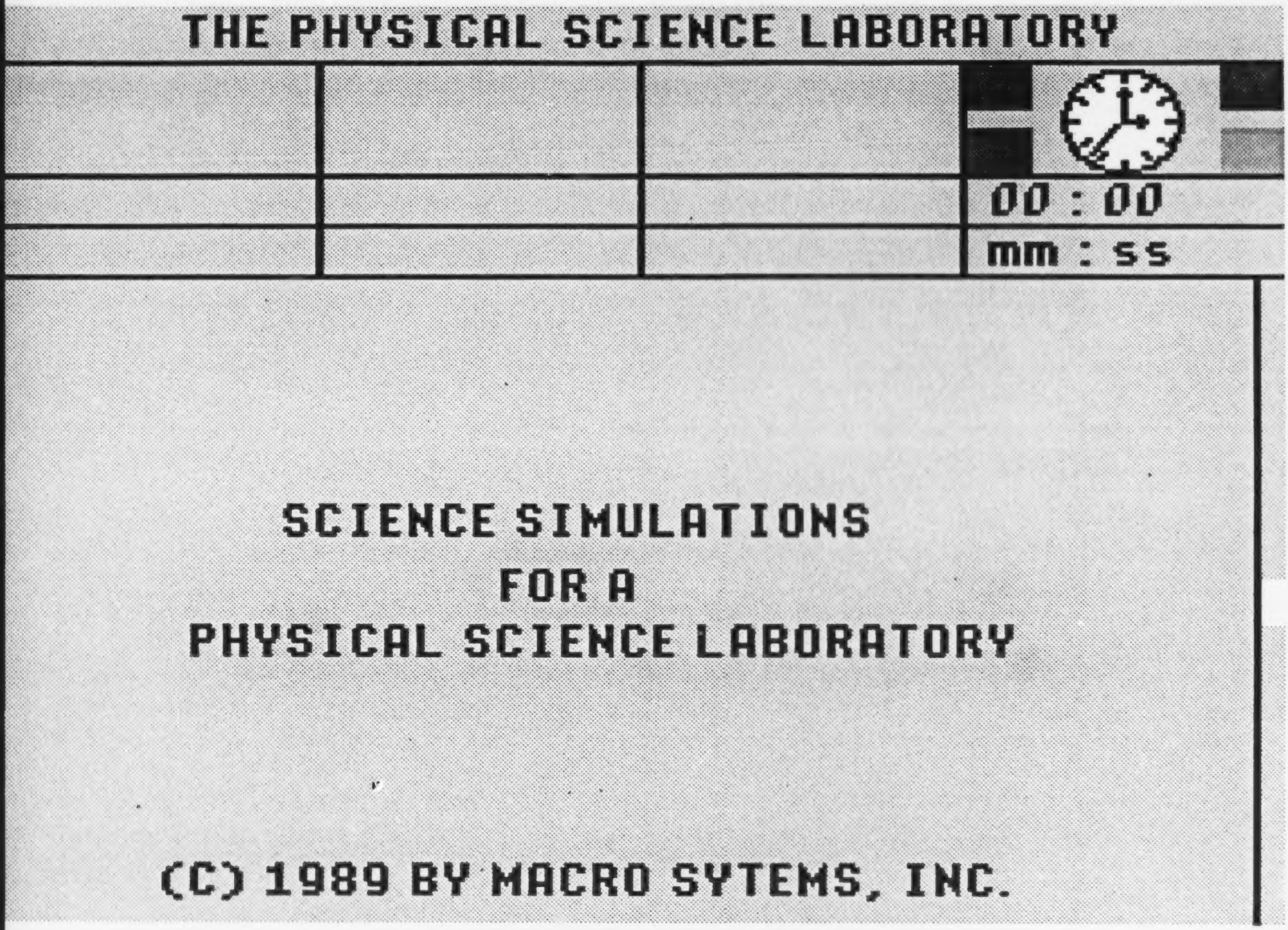

THE PHYSICAL SCIENCE LABORATORY

SCIENCE SIMULATIONS
FOR A
PHYSICAL SCIENCE LABORATORY

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# Science Simulations For A Physical Science Laboratory

## Teacher's Manual

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## PART I: Factors Influencing The Development Of This Software

### Statement Of Purpose

This software has been created to allow students to perform physical science experiments in a completely simulated experimental environment. The science simulations developed for this series are intended to complement any middle-school physical science curriculum. The simulations allow a student to perform physical science experiments using an **Apple II GS** computer system; no additional equipment is required. Using a "mouse," the student manipulates objects on the computer screen to affect the outcome of each experiment. The simulations are open-ended and experiments may be carried out in a structured or unstructured fashion to suit a particular teaching methodology.

Some of the objects and situations presented on the computer screen are similar to those that the student will encounter in the school laboratory; others place the student in familiar environments outside the school; still others exploit the computer's potential to create interesting experimental environments that would not normally be available to the student.

Problem sets have been developed (see the **Activity Worksheets**) for each simulation. The skills required to solve the problems start at the level of simple observation and advance through levels such as classifying, measuring, generalizing and predicting. A number of simulations are designed to help students gain competence in doing basic measurements. A consistent interface is used throughout all of the simulations.

**Note: The terms simulation and experiment are so closely related in the context of this discussion that they are used interchangeably.**

### Intended Audience

The science simulations are suitable for students with a wide variety of cognitive reasoning skills. Care has been taken to design the software to meet the needs of learning disabled and mildly mentally retarded students: particularly those who have been mainstreamed into a normal classroom environment.

## Special Features For Learning Impaired Students

Special features for learning impaired students include an emphasis on graphics rather than text to present key ideas; the use of a mouse instead of a keyboard for giving commands and for manipulating the experiments; the presentation of feedback in a non-judgmental manner, i.e., the absence of a formal reward/punishment system; voice synthesis of experimental data when requested by the user; a context sensitive help function that responds when the user points (with the mouse) to the object or location in question; the use of practical, familiar situations for introducing basic concepts; and a series of problem-solving environments that can be approached at different cognitive levels.

## Our Goals For The Student

1. Allow the student to perform physical science experiments wherever an appropriate computer is available.
2. Give the student greater control over the experimental environment than would be possible in the school laboratory.
3. Provide natural, unobtrusive and nonjudgmental feedback to the student during the course of each experiment.
4. Maximize the potential for inquiry learning by actively involving the student in the experimental process.
5. Allow for widely differing abilities among the students using the same software.
6. Create software that will **not** be perceived by students as being designed just for students with learning disabilities.
7. Provide software that will assist students in learning the basic competencies associated with physical measurement.
8. Present experimental situations that are fun and interesting: that often take place in familiar environments outside the school laboratory, but sometimes occur in exotic locations.
9. Create the opportunity to view an experiment under "ideal conditions" - those where the simplest assumptions apply - as well as under the more realistic conditions of a physical science laboratory.

## Our Goals For The Teacher

1. **Give the teacher control of the instructional process.**

   The software does not attempt to teach; it allows the student to learn by establishing problem-solving environments that enhance learning opportunities. Problems can be posed by the teacher or by the student.

2. **Provide feedback to the student in the absence of the teacher.**

   For example, the experiments dealing with basic measurements show a readable scale for each instrument, as well as a digital display of the value being measured. The digital reading can be observed at the same time as the scale reading, providing visual feedback to the student who is estimating the numerical value from the scale reading. The digital reading can easily be hidden or displayed to facilitate educated guessing of the scale reading. A synthesized voice can also be used to "speak" the displayed numerical value.

3. **Minimize the time needed to learn how to use the software.**

   Three different approaches are taken: video; guided hands-on activities; and profusely illustrated text. Each of these provides an introduction to the Physical Science Laboratory and its facilities. Refer to the Table Of Contents under **Introducing You To The Physical Science Laboratory** for information on where to find these materials.

   In addition, each program disk/simulation comes with an Introduction written especially for the teacher. When all else fails, refer to the appropriate Introduction.

4. **Provide the teacher with Activity Worksheets for each of the experiments.**

   The Activity Worksheets pose a series of experimental problems to be solved by the student. Space is provided on the Worksheets to write an answer to each question posed. Instructions to help solve the problem are also given on the same Worksheet, but it is often not necessary to read these before attempting a solution. The Worksheets may be duplicated and distributed to students as needed. The Worksheets are written for a Grade 6 reading level.

5. **Encourage the teacher to make instructional videos using this software.**

   The graphics used in the simulations have been drawn to be compatible with presentation on a standard color television set. When individual student use on the computer is not possible, the teacher can prepare lessons with voice accompaniment and store the results on video tape for use at any time.

## Technical Objectives Of The Designers

1. **Provide a simple and common interface to manage the simulations.**

   The interface is mouse-driven to avoid having to type in commands at the keyboard. Use of a mouse facilitates cursor movement for selecting various options at different positions on the screen, and for positioning experimental objects.

   The Physical Science Laboratory is laid out in a fixed but flexible arrangement. Many of the same screen locations and instruments can be utilized from one experiment to the next.

2. **Maintain technical accuracy in depicting physical events.**

   Observations and data obtained during these experiments are similar to those that would be obtained if the experiment were done under the same conditions in a real-world environment. Care has been taken to introduce numbers that reflect physical law as it is currently understood.

3. **Give the user control over the rate at which events occur during the experiments.**

   The Physical Science Laboratory comes equipped with a clock that can be speeded-up or slowed down. Speeding-up or slowing down the laboratory clock relative to a real world clock will cause the events occurring in the laboratory to speed-up or slow down, accordingly. Time can even be stopped to allow critical measurements to take place, or to position experimental objects in space.

4. **Produce video images that are compatible with standard color TV sets to facilitate the production and use of instructional videos.**

   Computer technology is capable of producing very high resolution graphic images on computer video screens. Unfortunately these images can not be reproduced on a standard classroom or home TV set. Attempting to do so usually results in a blurry, sometimes unrecognizable image appearing on the TV screen. Care has been taken in the production of the graphics for these experiments to assure their viewability on a standard TV set. Teachers can use these images to prepare instructional videos on a VCR that can be played back on any home TV set.

   Preparing computer-assisted instructional videos on the Apple II/GS computer requires connecting a cable from the composite-video-out plug on the back of the computer to the video-in plug on a standard VCR. The signal from the computer is then recorded in the same fashion as you would record a signal from a TV program or video camera. Some VCR's feature audio dubbing, which will allow the recording of voice over the video image. The video introductions for these simulations were prepared in this fashion.

## Educational Benefits Of Computer Simulation

1. **Computer simulation allows the possibility of doing experiments without requiring the resources normally associated with a science lab.**

   Safety considerations, consumption of resources, and protection of laboratory equipment preclude the student from doing experiments at school in an unscheduled or unsupervised fashion. Finding time on a school computer can often be easier than gaining access to the school science lab.

2. **Computer simulation can be used to illustrate the "ideal" behavior of physical phenomena - the behavior associated with the simplest assumptions of physical law.**

   The variables that affect actual behavior can be introduced and controlled, one at a time, to show how they modify the simpler behaviors. The differences between an "ideal" environment - for example, one without friction - and a real-world environment can be plainly demonstrated.

3. **Computer simulation can be used to regulate the time it takes to do an experiment.**

   Time can be slowed down or speeded up to suit the needs and temperament of the experimenter. A student with a learning disability can cause the experiment to proceed at a pace that is compatible with his or her skills.

   Time can be suspended (like taking a high-speed photograph) in order to facilitate the taking of measurements or the arrangement of equipment. For example, to position an object for a free-fall experiment, one need only stop time, move the object to a given height above ground, and then start time to begin the fall. Time can be slowed down to make the object appear to be falling slower, if necessary. Since the time clock and the events are synchronized, the data derived from any experiment will always have the proper relationship to real time.

4. **Computer simulation coupled with computer graphics can be used to create problem-solving environments that are not normally accessible to the student, and at the same time provide a high degree of scientific interest.**

   For example, certain experiments in the Physical Science Laboratory series may be moved quickly between the earth and the moon, so that the same experiment can be performed in both places and the results compared. While on the earth, the student views a suburban landscape in the background, while on the moon he or she is presented with a starlit sky and a craggy lunar surface.

5. **Computer simulation coupled with a VCR can be used to create video demonstrations of physical phenomena.**

   The video demonstrations can, of course, be narrated by the teacher. The teacher can prepare a video library of ready-made demonstrations for instructional purposes.

## Part II: Operating the Physical Science Laboratory

### Hardware: What You Need

The hardware required to run the simulations in the Physical Science Laboratory includes an Apple II GS computer, a color monitor, a mouse (single-button preferred), one or two 3.5-inch disk drives, and 768K bytes of RAM memory.

**Note that 768K bytes of memory represents an increase of 256K over the standard Apple II GS.**

### Software: What You Need

Start your computer with the **System Disk** included with this teacher's manual. If you have two 3.5-inch disk drives, leave the system disk in one of the drives while running the simulations. If you only have one 3.5-inch drive, follow the instructions for swapping disks that will appear on the computer screen from time to time.

Each simulation in the Physical Science Laboratory is supplied on a separate 3.5-inch **program disk**. Each program disk is labeled with an experiment number and title. The program disk, labeled **Experiment 0: The Physical Science Laboratory**, is supplied with this teacher's manual to help acquaint you with the Physical Science Laboratory in a hands-on fashion.

### Running The Simulation Programs

### Starting Up

Place the **System Disk**, which accompanies the teacher's manual, into a 3 1/2 inch disk drive. Turn on or reboot the computer. (To reboot press and hold the **Control**, **Apple and Reset** keys in that order, then release them in the reverse order. The reset key is all by itself at the top of the keyboard.)

Place the program disk containing the simulation you wish to run in the other 3 1/2 inch drive (or swap it with the system disk if you have only one drive). A disk icon will appear on the screen with the same name as that written on the disk label.

A window will emerge from the disk icon. **Double Click** on the icon which appears in that window. The screen will go blank except for the phrase "Launching:" followed by a file name. In about 30 seconds the title screen for this disk will appear. The title screen contains information about the experiment being run and the registered user to whom the disk belongs. The title screen will be displayed for a few seconds, followed by the starting screen for the current experiment.

Using the mouse and the mouse pointer you are now ready to start the experiment. For best results, look over the Introduction to the current experiment in the Activity Worksheet Series. For suggested activities refer to the worksheets, themselves.

## Quitting

To quit and return to the operating system:

Normal Exit

First: **click on** the blue **gadget** (rectangle) appearing in the **Clock window** in the upper right-hand corner of the screen. A **menu** will appear at the top of the screen. You will currently be in the **menu mode.**

Second: click on the **QUIT** word appearing in the menu.

Third: remove the disk containing the simulation experiment from the drive. If you want to get fancy you can drag the disk **icon** for this experiment onto the trashcan icon, which should be on the screen at this time. The experiment disk will then eject automatically, and its icon will disappear from the screen.

Exceptions:

1. If you are already in the menu mode simply click on the **QUIT word.**

2. If you are in the help mode (the word **HELP** appears in reverse video (white on black)), then click once or twice on the **CONTINUE** word and follow the instructions for a normal exit above.

## Part III: Documentation And Support Materials

### The Activity Worksheet Series

Every program disk for the Physical Science Laboratory is accompanied by a set of documents known collectively as the **Activity Worksheet Series.** The first of these documents for each program disk is a detailed introduction to the simulation environment presented on that disk. The remainder of the documents for each program disk are a series of **Activity Worksheets** that pose experimental problems to the student. The worksheets are designed to be filled out while solving an experimental problem.

The introductory document of each simulation describes the objectives we had in mind when we created the simulation, and also describes the special features associated with that simulation. It is here that you will find a detailed description of how to manipulate an instrument, or move an object in the experimental environment. A picture of some phase of the simulation always appears on the first page of the introductory document.

For easy identification, each **Activity Worksheet** in the series has a number and a title: for example, **Worksheet 1-1: Using The Elapsed Time Clock.** The first part of the number indicates the experiment, and the second part identifies one of a number of experimental problem sets associated with this experiment. Each Activity Worksheet contains several problems designed to be answered directly on the worksheet.

## Introducing You To The Physical Science Laboratory

### Video Introduction - Watch And Listen

Three short videos appearing on one video tape are packaged with this teacher's manual. The first video, entitled **"Using A Mouse"**, should be considered must viewing for anyone unfamiliar with mouse terminology. The second video, **"Touring The Lab"**, takes you through the basic features of the Physical Science Laboratory. Finally, the third video, **"A Sneak Preview"**, gives a brief look at some of the experiments in this series.

## Hands-On Introduction - Try It Yourself

After viewing the introductory videos, you're ready for hands-on practice using the Physical Science Laboratory. This hands-on introduction uses the depiction of the lab on your computer screen, together with the **Activity Worksheets** for Experiment 0, to acquaint you with the permanent features of the Physical Science Laboratory.

To begin, get a copy of **Worksheet 0-1: Touring The Physical Science Laboratory**. Find the program disk labeled **Experiment 0: The Physical Science Laboratory**. You will also need to locate the disk labeled **System.Disk** that was supplied with the teacher's manual.

**Note: You must use the system disk that we supply, otherwise the programs will not load or function properly.**

Follow the instructions on page 7 under the heading **Starting Up** in order to load the Experiment 0 program disk.

Next, using Worksheet 0-1: complete the exercises found on this worksheet. The exercises appear as a series of problems to be solved. The problems appear in shaded boxes on the worksheet. If you can't solve the problem from the information given in the shaded box, read the instructions beneath the problem statement. The activities in Experiment 0 are designed to acquaint students and teachers alike with the Physical Science Laboratory.

When you have finished Worksheet 0-1, go on to 0-2.

**Note: We strongly recommend that you complete all of the Activity Worksheets for Experiment 0 before moving on to any of the other program disks.**

These activities are designed to familiarize you with the names and locations of places and things in the lab, as well as give you practice in using the equipment.

When you are done or want to quit, follow the instructions under the heading **Quitting**, which you can find on page 8.

## Text Introduction - Read About It

For a written description of the Physical Science Laboratory see the document titled **Introduction To Experiment 0: The Physical Science Laboratory**, which is part of the **Activity Worksheet Series**. This document provides a complete introduction to the names and locations of the permanent features of the lab. This introduction can be found with the **Activity Worksheets** accompanying the Experiment 0 program disk.

## Part IV: Suggested Instructional Methodologies

### With Children In General

### Video Introduction

Before showing the video **Using A Mouse** to a student, give them Activity Worksheet 0-1: **Touring The Physical Science Lab.** They can check off the "Mouse Words" on the first page as they watch the video.

Worksheet 0-1 also includes a picture of the lab. Before showing the video **Touring The Lab** give them their copy of Worksheet 0-1. As they follow the video they can note the positions in the lab on the Worksheet picture. They won't have time to write the names in during the video presentation, but the initial association of place and name can be reinforced if the picture is in front of them.

### Pretesting For Basic Measurement Skills

Some of the experiments are designed to help children learn to make measurements of elapsed time, length, and temperature. In the real world environment making measurements usually involves reading the scales of the measurement instruments. To assess their skill at reading the scale of a ruler and a thermometer, try having them solve the problems on the following Worksheets before sitting down at the computer.

Worksheet 4-3: Ruler With 1/10 Inch Scale Divisions

Worksheet 5-5: Reading A Circular Thermometer

Worksheet 6-6: Reading A Thermometer

### With Learning Disabled Children

For learning disabled children who have not acquired the basic measurment skills, a one-to-one student teacher ratio works best with these materials. The teacher can direct questions at the student without having to worry about distractions caused by the presence of another student or students. Once students have mastered the basic measurement skills, they can work in pairs to complete the activities; the presence of a teacher is optional, but often depends on the personalities and disabilities of the individual students.

# Glossary

| **Glossary:** | **Mouse Terminology** |
|---|---|
| **Click** | To **click**, tap one of the buttons on the mouse once with your finger. Some mice have more than one button. Use the left button if your mouse has more than one. |
| **Click On** | To **click on**, move the mouse pointer to the desired screen location and click the mouse button once. |
| **Double Click** | To **double click**, tap one of the buttons twice in rapid succession. Except for operating system commands, double clicks are not required when using this software. |
| **Drag** | To **drag** an icon to another location on the computer screen, move your mouse pointer to the icon and press the mouse button. Move the mouse until the icon is repositioned on the screen. Release the mouse button. |
| **Gadget** | A location on the screen that is associated with a specific function. For example, clicking on the STOP gadget in the Physical Science Laboratory causes the clock to stop. |
| **Icon** | A representational figure on the computer screen that you can control with the mouse. |
| **Mouse** | A hand-held device with one or more buttons that you can roll around your desktop. As you move the mouse, a figure on the computer screen moves in a similar direction. |
| **Mouse Pointer** | An arrow or other directional figure on the computer screen that moves in conjunction with the mouse. |
| **Press** | To **press**, hold the mouse button down until the desired task on the computer screen has been completed. |
| **Release** | When you **release** the mouse button, you conclude a press operation. A very fast press and release is a click. |
| **Select/Choose** | Click on a specified gadget. |

## Physical Science Laboratory Terminology

| | |
|---|---|
| **Activity Worksheet** | A set of problems designed like a laboratory worksheet for use with a particular experiment. Experimental problems are posed and space is provided to write out each answer. Instructions for operating the software and suggestions for solving the problems are included. |
| **Activity Worksheet Series** | The written materials accompanying the simulation software. For each disk this includes an Introduction to the experiment and a set of **Activity Worksheets** that pose experimental problems for the student. |
| **Clock** | See **Elapsed-Time Clock**. |
| **Clock Gadgets** | The colored rectangles appearing with the **Clock** icon in the **Clock Window.** Starting from the upper-left corner of the window and proceeding clockwise they are colored green, red, yellow and blue. They are know respectively as the **START** button, **STOP** Button, **RESET** Button, and **MENU** Button or Menu Gadget. |
| **Clock Instrument Window** | See **Clock Window**. |
| **Clock Speed-Control** | See **Speed-Control**. |
| **Clock Window** | **Instrument Window** number 4. The instrument window containing the **Elapsed-time** clock. |
| **CONTINUE Word** | One of the choices in the **Menu Mode.** Causes the next logical activity in the menu mode to occur: either clearing a **Help Window** from the screen or returning the user to normal operation of the Physical Science Laboratory. |

| | |
|---|---|
| **Elapsed-Time Clock** | Pictorially this is the clock icon residing in the **Clock Window** in the upper-right corner of the computer screen. The hands on the clock icon do not move. Experimentally the clock is used to measure **and control** the advance of time during any experiment. The clock may be started, stopped and reset using the **Clock Gadgets**. Experimental activity takes place when the clock is running and is held in abeyance while the clock is stopped. The current value of the elapsed time is shown in the **Value Bar** of the clock window. The selected units are shown simultaneously in the clock **Units Bar**. |
| **Help Mode** | An operating mode in which an active menu is present in the **Menu Bar**. Selecting any location on the screen (except in the Menu Bar itself) will cause a **Help Window** to appear in the center of the screen. To exit the Help Mode you must click on the **CONTINUE Word** twice. |
| **Help Window** | A **Window** containing text that is used to describe a feature of the Physical Science Laboratory. Help Windows are normally accessed by clicking on a given object or location while in the **Help Mode**. The Help Window will contain the name of the location or object that was last selected and a brief description of that location or object. The **SPEAK Word**, available in the Menu Bar at this time, can be selected to cause the computer to voice the words appearing in the Help Window. To access another Help Window you must first click on the **CONTINUE Word** in the **Menu Bar**. |
| **HELP Word** | One of the choices in the **Menu Mode**. Clicking on the HELP Word causes the HELP word itself to appear in reverse video. This indicates that the program has entered the **Help Mode**. |
| **Lab Bench** | The area in the Physical Science Laboratory used to display and perform the current experiment. Comprises most of the display area but does not include the **Menu Bar**, the **Instrument Windows**, or the **Slide Bar**. |

| | |
|---|---|
| **Instrument Shelf** | The upper half of an **Instrument Window**. Used primarily to store instruments and lab equipment. These may usually be dragged or moved to other locations in the lab for measurement purposes. |
| **Instrument Window** | A location in the **Physical Science Laboratory**, always visible on the computer screen, used for storing measurement instruments, control instruments and equipment, and for displaying the numerical value and units of measurement associated with an instrument reading. Occasionally, purely descriptive information will appear in an instrument window. The window itself is made up of three parts: the **Instrument Shelf**, the **Value Bar**, and the **Units Bar**. There are four instrument windows in the laboratory. The windows are located just below the **menu bar** at the top of the screen. |
| **Menu** | A set of words located in the **Menu Bar** at the top of the computer screen. |
| **Menu Bar** | Approximately the top 1 centimeter of the computer screen that is visible when running the simulation software. Normally the title of the current experiment is displayed in the menu bar until the **Menu Gadget** is selected. |
| **Menu Gadget** | The blue rectangle in the lower-left corner of the **Clock Instrument Shelf**. Clicking on the Menu Gadget while operating the experiment causes all experimental activity to cease and a **Menu** to appear. |
| **MENU Button** | See **Menu Gadget**. |
| **Menu Mode** | An operating mode in which an active menu is present in the **Menu Bar**. Selecting one of the words in the menu bar will cause the corresponding activity to occur. The menu mode is attained by selecting the **Menu Gadget**. |
| **Next Gadget** | A white rectangle that may appear in any one of the first three **Instrument Shelves**. Used to rummage around on an instrument shelf for additional instruments or equipment that may be stored there. Clicking on the next gadget will cause the current instrument to disappear and the next one in line to appear. Continued clicking will allow the user to cycle through the available instruments or equipment stored on that shelf. |

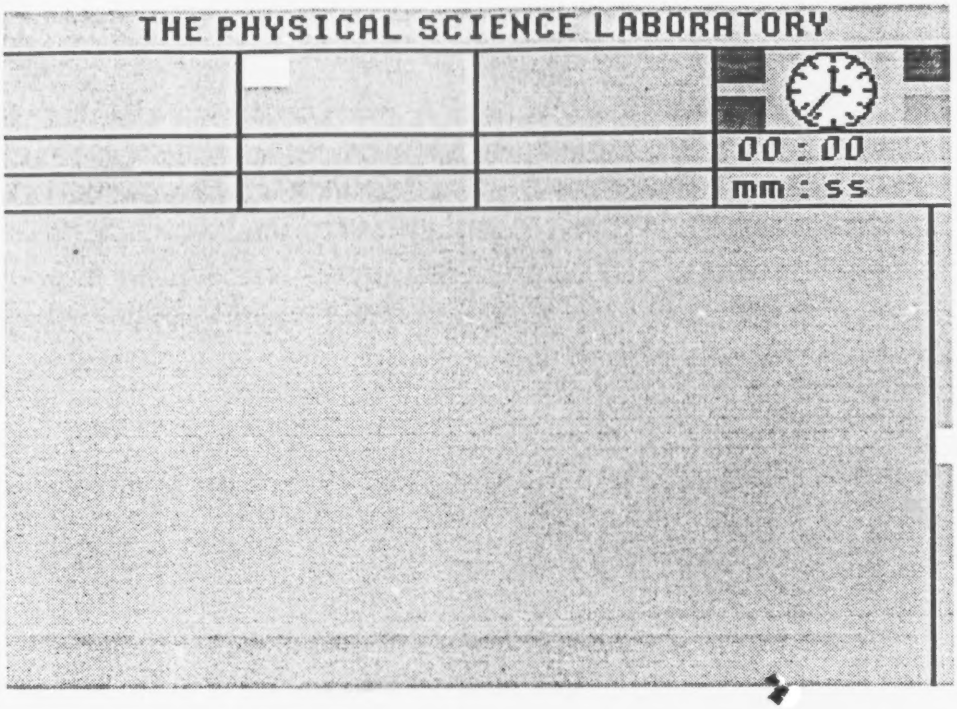
| | |
|---|---|
| **Program Disk** | A 3 1/2 inch disk containing the computer program and graphic displays necessary for simulating a given experimental environment. |
| **QUIT Word** | One of the choices in the **Menu Mode**. Causes the simulation program to stop running and returns control to the Apple II GS operating system. |
| **RESTART Word** | One of the choices in the **Menu Mode**. Causes the current simulation to start over from the very beginning. Same results as clicking on the disk icon for the experiment disk. |
| **RESET Button** | The yellow **Clock Gadget** in the lower-right corner of the **Clock Instrument Shelf**. Clicking on the RESET button once has the same effect as clicking on the **STOP Button**. Clicking on the RESET button a second time before the **Clock** is restarted causes the elapsed time on the clock to be set to zero. The experiment remains inactive until the clock is started. |
| **Slide Bar** | Provides the boundaries for movement of the **Clock Speed Control**. Appears as a narrow rectangle on the right-hand side of the computer screen below the **Clock Instrument Window**. |
| **SPEAK Word** | One of the choices in the **Help Mode**. Clicking on the SPEAK Word causes the text appearing in the current **Help Window** to be voiced by the computer. |
| **Speed-Control** | A device for controlling the rate at which time advances in the Physical Science Laboratory relative to a real-time clock. The speed-control is used to speed time up, where possible, and to slow it down, when necessary. It appears as a small, white rectangle in the **Slide Bar**. Dragging it up, speeds up time; dragging it down, slows time down. The factor by which time is affected may be read in the **Clock Value Bar** while adjusting the position of the speed-control. Note that adjustments by the user can only be made while the clock is stopped. While the clock is running, the speed-control factor may be seen momentarily by clicking on the speed-control itself. The amount of adjustment possible depends on the experiment. If an experiment can only run more slowly than real-time, the speed-control will adjust its position automatically to indicate the factor at which the experiment is running. |

| | |
|---|---|
| **START Button** | The green **Clock Gadget** in the upper-left corner of the **Clock Window.** Clicking on the START button starts the **Elapsed-Time Clock** and experimental activity at the same time. |
| **STOP Button** | The red **Clock Gadget** in the upper-right corner of the **Clock Window.** Clicking on the STOP button stops the **Elapsed-Time Clock** and experimental activity at the same time. |
| **System Disk** | The disk containing the Apple II GS operating system. You must use this operating system when running the science simulations. |
| **Teacher's Manual** | A guide to the simulation software. Contains sections describing the development philosophy, mechanics of operation, documentation and support material, suggested instructional methodologies, two glossaries - one for mouse terminology, and one for the Physical Science Laboratory terminology - and an appendix on preparing instructional videos. |
| **Thermometer Instrument** | One of a number of measurement instruments. This one is designed to measure the temperature of places or objects in the Physical Science Laboratory by dragging the thermometer icon to the desired location and releasing it at that point. The temperature will be monitored as long as the thermometer icon is on the **Lab Bench**. The value of the temperature may be read in the **Value Bar** of the **Instrument Window** from which the thermometer was obtained. The units of temperature will appear in the associated **Units Bar**. The numerical reading will be voiced by the computer whenever the thermometer is moved to a new location and the value bar is not in its hidden state. The numerical value will also be voiced by the computer whenever the user clicks on the value bar and causes the numerical value to reappear from its hidden state. |

| | |
|---|---|
| **Units Bar** | The bottom section of an **Instrument Window**. Normally used to display the units of measurement associated with the numerical value that is being displayed in the **Value Bar**. Clicking on the units bar causes the unit of measurement to change to some other unit. Continued clicking will allow the user to cycle through the available units of measurement. The value in the **Value Bar** will change automatically to correspond with the current unit of measurement. The value bar may also be used to display descriptive information about equipment appearing in that window. |
| **Value Bar** | The middle section of an **Instrument Window**. Normally used to display the numerical value associated with a measurement or control instrument that is active in that window. Active instruments are those that have been obtained from the **Instrument Shelf** of that window and are currently visible. Clicking on the value bar will cause the numerical information displayed there to be hidden from view. Clicking again will cause it to reappear. Whenever the value bar is in its hidden state, voice synthesis of the numerical value will be suppressed. The value bar may also be used to display descriptive information about equipment appearing in that window. |
| **Window** | A rectangular area appearing at some location on the computer screen. Normally its perimeter is drawn in a color that contrasts with the background color of the screen. The interior of the window is used to display text or graphics. Windows may be a permanent or temporary feature of the experiments. |

# Introduction to Experiment 0:

# The Physical Science Laboratory


THE PHYSICAL SCIENCE LABORATORY
00 : 00
mm : ss

**Experiment 0: The Physical Science Laboratory**
**Figure 1: Permanent Features**

## Objectives

This environment is designed to point out the important features of the Physical Science Laboratory that will be common to many of the experiments in this series. The names of the various locations in the laboratory are introduced. Descriptions of the permanent fixtures are given.

## Features

### General Description:

The Physical Science Laboratory enables the student or teacher to perform physical science experiments in a simulated experimental environment. The experiments take place on the computer screen. All the equipment and measurement instruments are part of the simulation; no external devices are necessary.

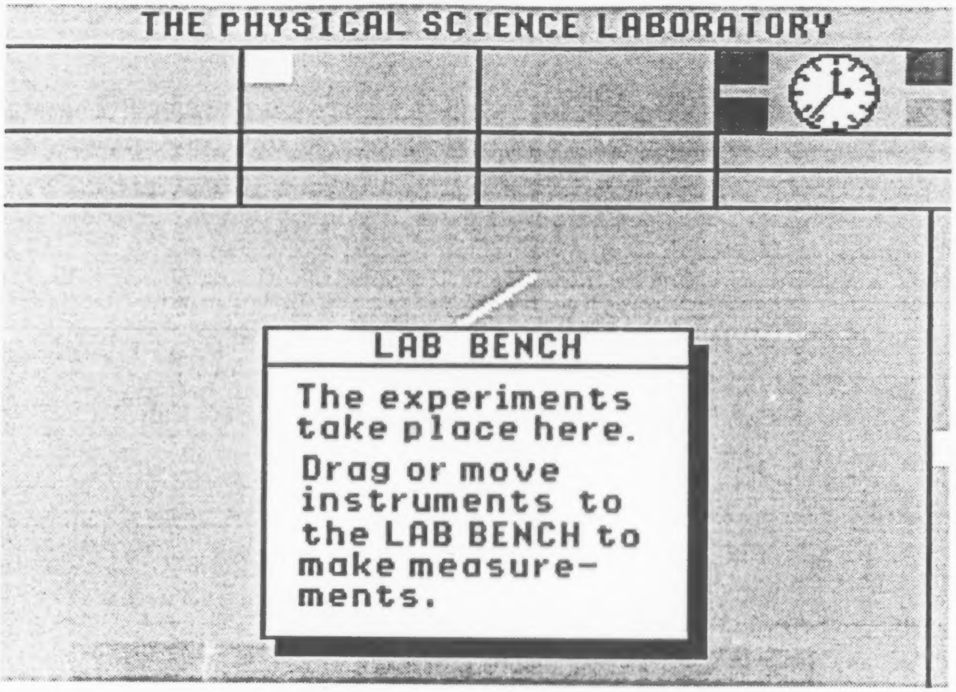
The laboratory, as it appears on the computer screen, is divided into several important locations including the **lab bench**, the **instrument windows**, the **menu bar**, and the **slide bar** for the **clock speed-control**. Each instrument window is further subdivided into an **instrument shelf**, a **value bar**, and a **units bar**.

The **elapsed-time clock** is a permanent fixture of the laboratory as well as its associated clock speed-control. A **next gadget** sometimes appears to enable the experimenter to search an instrument shelf for other instruments or equipment.

Experiments take place on the lab bench. Depending on the experiment, various pieces of equipment appear as needed on the lab bench. Other equipment and measurement instruments can be obtained from the instrument shelves.

The scene depicted on the lab bench also varies for different experiments. It can appear as a table top (thus the "lab bench" designation) in one experiment, or a mountainous, outdoor vista in another.

Using only the mouse as an input device, experimental objects are manipulated, time is controlled, and measurements are taken. The numerical values of the measurements appear in the value bars of the various instrument windows as the measurement process is taking place. The data generated from these simulations can be recorded and analyzed in the same fashion as data from any real-world experiment.



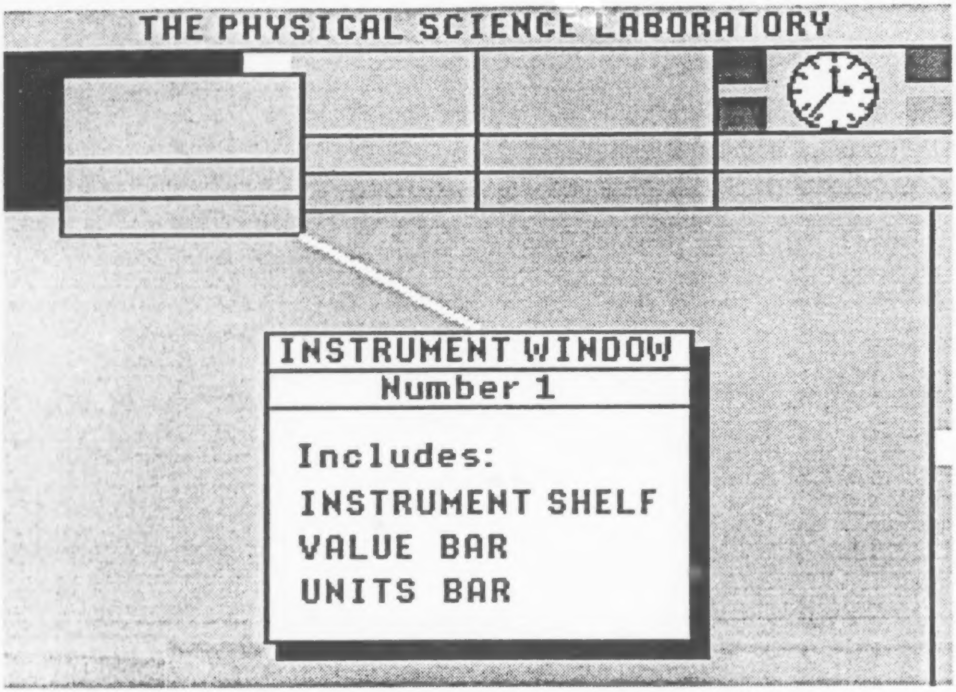
LAB BENCH

The experiments take place here.

Drag or move instruments to the LAB BENCH to make measurements.

**Experiment 0: The Physical Science Laboratory**
**Figure 2: The Lab Bench**

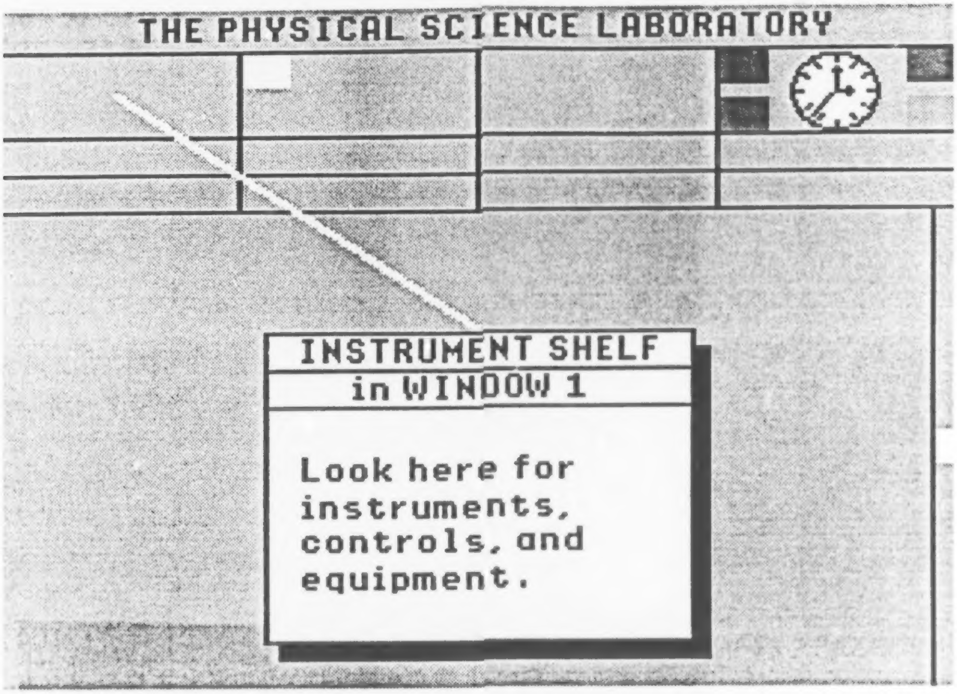
The lab bench occupies the lower and major portion of the Physical Science Laboratory. All experimental activity takes place on the lab bench. This activity may include controlling or moving equipment that is located there. It may also involve bringing instruments to the lab bench, such as thermometers and rulers, in order to do measurements.


THE PHYSICAL SCIENCE LABORATORY
INSTRUMENT WINDOW
Number 1
Includes:
INSTRUMENT SHELF
VALUE BAR
UNITS BAR

**Experiment 0: The Physical Science Laboratory**
**Figure 3: Instrument Window Number 1**

An **instrument window** is a location for storing measurement instruments, control instruments and equipment, and for displaying the numerical value and units of measurement associated with an instrument reading. Occasionally, purely descriptive information will appear in an instrument window.

Instrument Window Number 1 appears near the top left-hand portion of the screen, as shown in Figure 3. There are three other instrument windows in the laboratory numbered 2 through 4, respectively. Each window is divided into three sections. The top section is called the **instrument shelf**, the middle section is known as the **value bar**, and the bottom section is called the **units bar.**



THE PHYSICAL SCIENCE LABORATORY

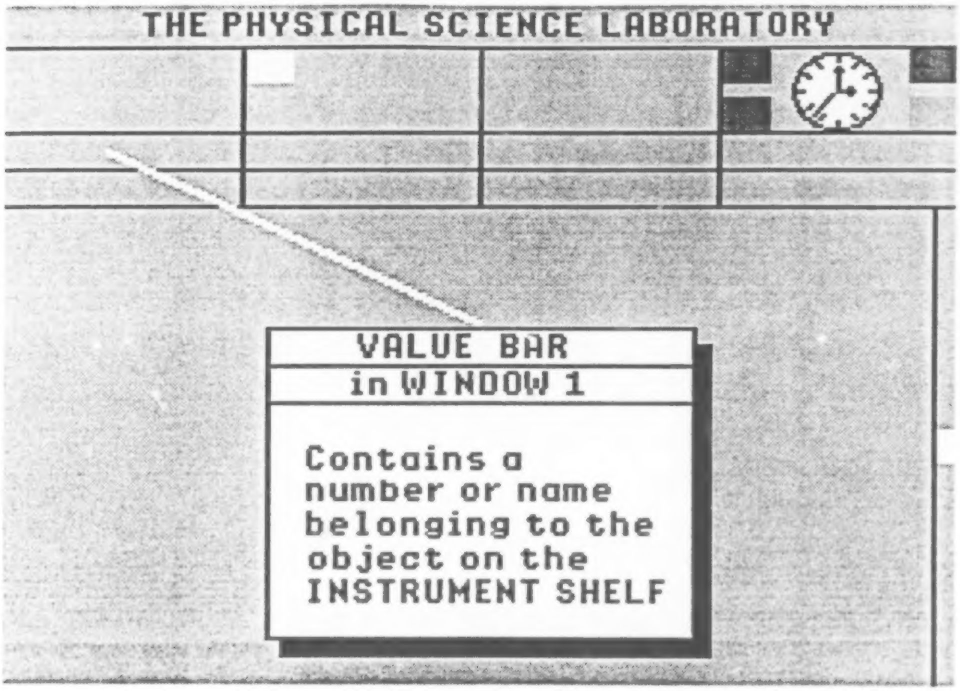
INSTRUMENT SHELF in WINDOW 1

Look here for instruments, controls, and equipment.

**Experiment 0: The Physical Science Laboratory**
**Figure 4: Instrument Shelf In Window Number 1**

The **instrument shelf** is used to store instruments and equipment. A measurement instrument can be removed from the shelf by **dragging** it with the mouse to the lab bench. A control instrument, such as an oven thermostat, may remain on the shelf and be used to control a piece of equipment, such as an oven that is sitting on the lab bench. Other equipment that may prove useful during experiments - pencils, erasers, hourglass timers, etc. - can also be found on the instrument shelves.

Each instrument window interacts with the instruments that are stored on the instrument shelf of that window. When an instrument is visible and actively measuring experimental data, the numerical value associated with that measurement appears in the **value bar** of that instrument window, and the units of that measurement appear in the **units bar**.



VALUE BAR
in WINDOW 1

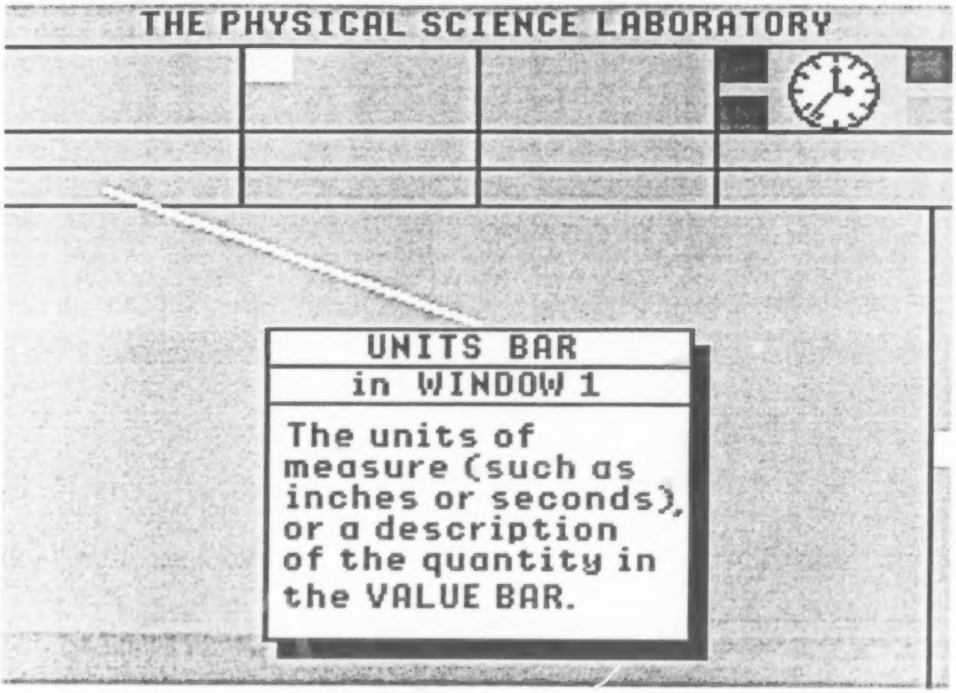
Contains a
number or name
belonging to the
object on the
INSTRUMENT SHELF

**Experiment 0: The Physical Science Laboratory**
**Figure 5: Value Bar In Window Number 1**

The primary use of the **value bar** is to display the numerical value associated with the measurement instrument that is currently active in that window. There may be several instruments or pieces of equipment associated with a window, but only one may be active at a time. The active instrument is the one that is visible and is residing on the shelf, or is visible and has been moved to a location on the lab bench.

Another use of the value bar is to display information associated with a piece of equipment that is currently active in that window. The exact nature of the display depends on the item in question.

Clicking on the value bar causes the number to disappear behind a white bar if the value is currently displayed; clicking when the number is obscured will cause it to reappear.



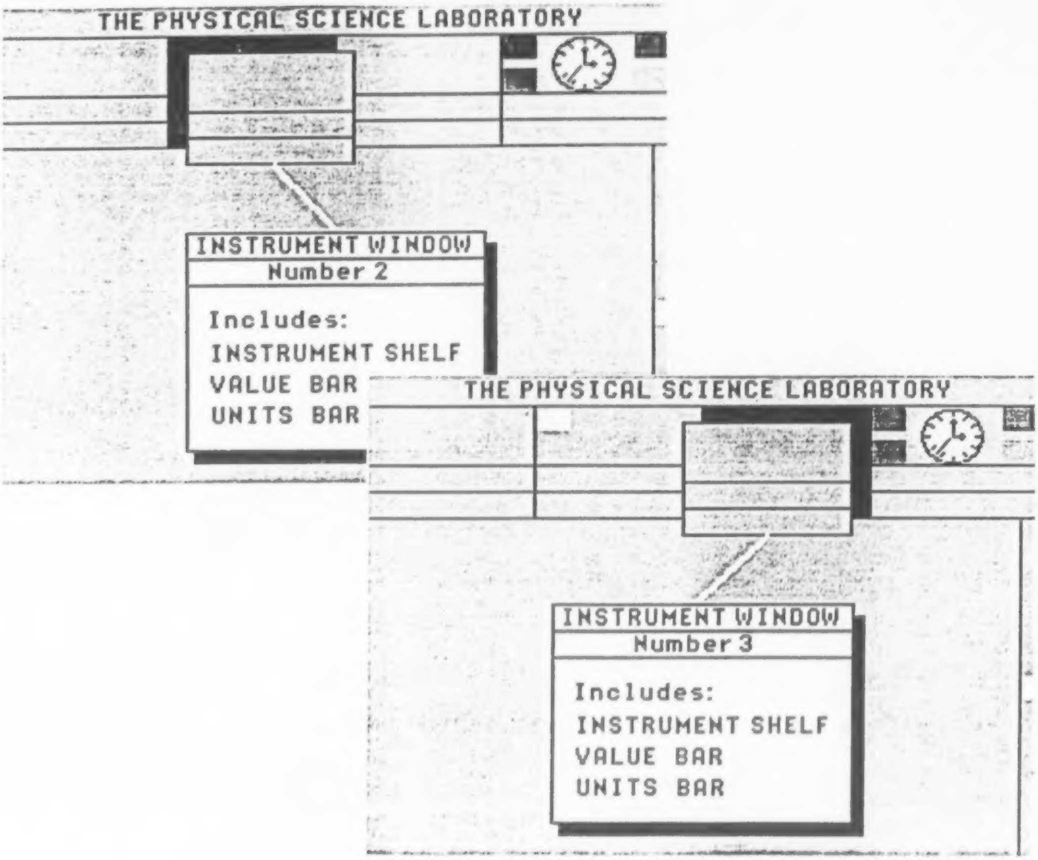
The units of measure (such as inches or seconds), or a description of the quantity in the VALUE BAR.

**Experiment 0: The Physical Science Laboratory**
**Figure 6: Units Bar In Window Number 1**

The primary use of the **units bar** is to display information associated with the units of measurement of the number appearing in the **value bar**. For example, the units bar may display the term inches, or the abbreviation cm, if the ruler instrument is in use.

Clicking on a units bar will cause the unit of measurement displayed there to change to some other unit of measure. The associated numerical value in the value bar will change at the same time. For example, if the unit of measure displayed in the value bar is inches, clicking on the units bar may change the display to cm. If the value bar originally showed 1.00, it would change to 2.54. Continual clicking on the units bar will allow the user to cycle through the available units.

The units bar may also be used to display purely descriptive information at various times.


THE PHYSICAL SCIENCE LABORATORY
INSTRUMENT WINDOW
Number 2
Includes:
INSTRUMENT SHELF
VALUE BAR
UNITS BAR
THE PHYSICAL SCIENCE LABORATORY
INSTRUMENT WINDOW
Number 3
Includes:
INSTRUMENT SHELF
VALUE BAR
UNITS BAR

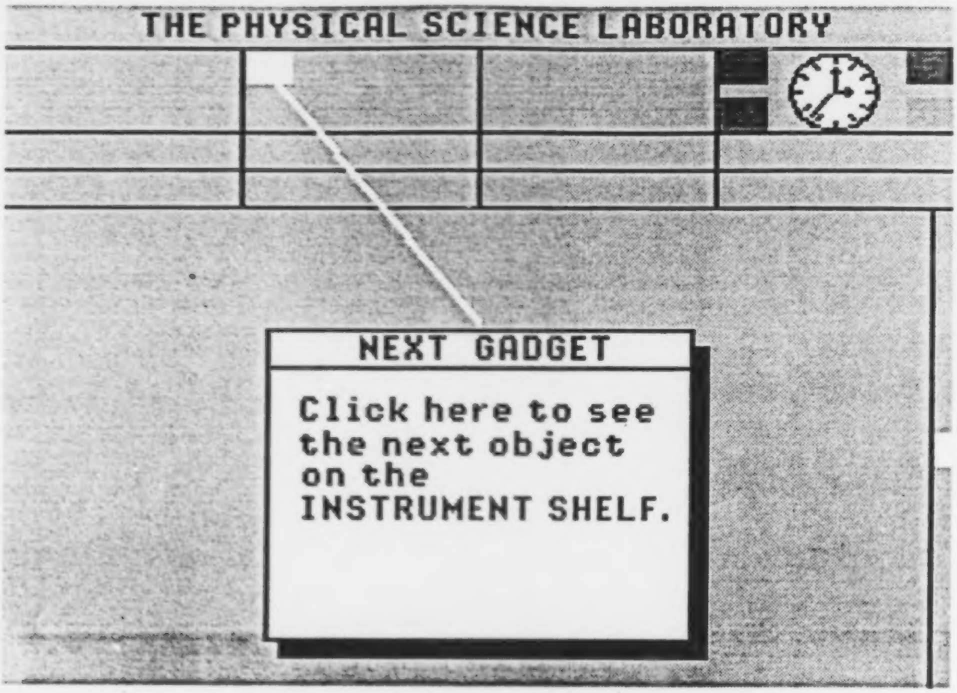
**Experiment 0: The Physical Science Laboratory**
**Figure 7: Instrument Window Numbers 2 And 3**

**Instrument windows numbers 2 and 3** have the same characteristics as instrument window number 1. The different windows are sometimes referred to by their numbers, but are often named by the instrument that is active in a particular window. For example, if the thermometer instrument is visible in window 3, that window may be referred to as the thermometer instrument window or the thermometer window. The value bar in that same window would be called the thermometer value bar. Similarly the units bar would be called the units bar for the thermometer.

figure

**Experiment 0: The Physical Science Laboratory**
**Figure 8: Example Of A Next Gadget**

Occasionally an instrument window or the lab bench will contain a **next gadget**. Next gadgets are displayed as small white rectangles. Next gadgets are used to indicate that other instruments or equipment are residing at the same location, but are not visible. Clicking on the next gadget will cause the "next" item at that location to become visible, replacing the item that was currently visible, or filling the void if nothing was there.

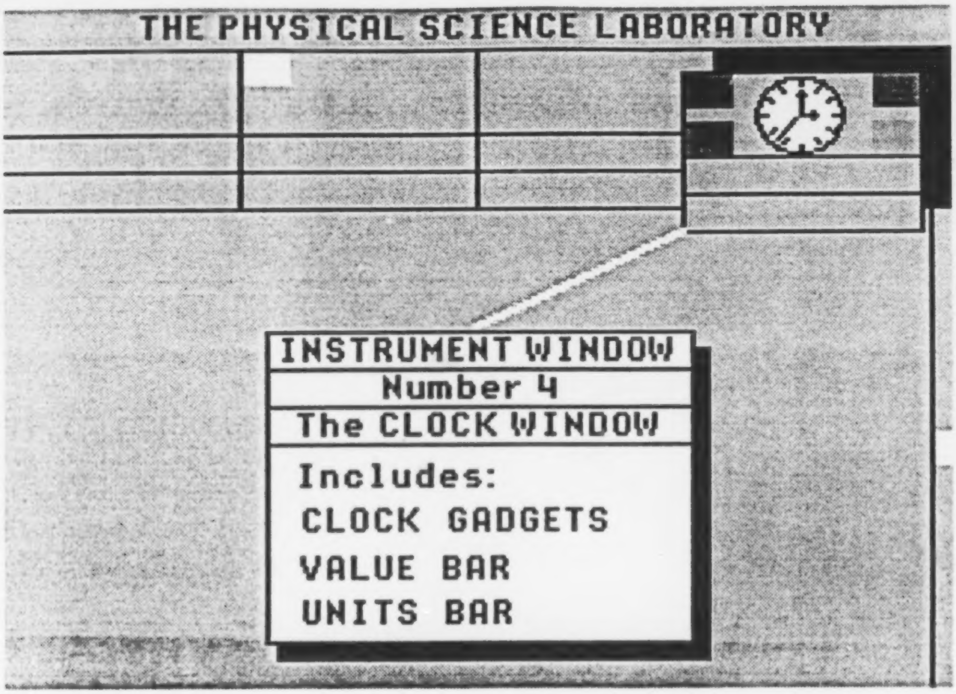

THE PHYSICAL SCIENCE LABORATORY

NEXT GADGET

Click here to see the next object on the INSTRUMENT SHELF.

**Experiment 0: The Physical Science Laboratory**
**Figure 8: Example Of A Next Gadget**

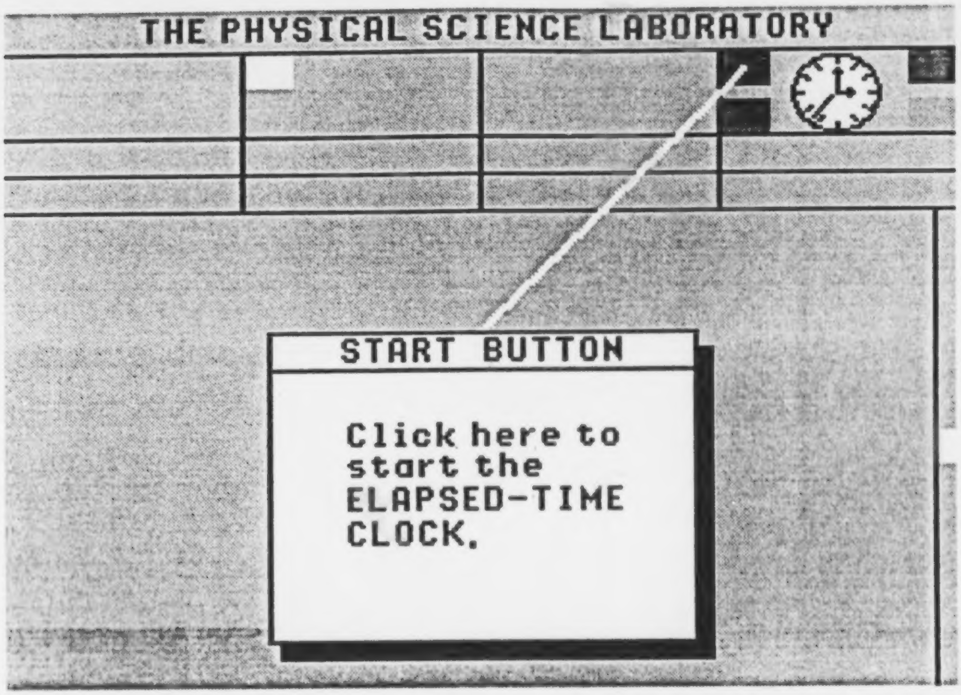
Occasionally an instrument window or the lab bench will contain a **next gadget**. Next gadgets are displayed as small white rectangles. Next gadgets are used to indicate that other instruments or equipment are residing at the same location, but are not visible. Clicking on the next gadget will cause the "next" item at that location to become visible, replacing the item that was currently visible, or filling the void if nothing was there.


THE PHYSICAL SCIENCE LABORATORY
INSTRUMENT WINDOW
Number 4
The CLOCK WINDOW
Includes:
CLOCK GADGETS
VALUE BAR
UNITS BAR

**Experiment 0: The Physical Science Laboratory**
**Figure 9: Instrument Window Number 4**

The fourth instrument window is also known as the **clock instrument window**. Like the first three instrument windows, it is comprised of a shelf, a value bar, and a units bar. Sitting on the shelf is the measurement instrument known as the **elapsed-time clock**. The elapsed time clock, or simply - the clock - is a permanent fixture of the Physical Science Laboratory. Surrounding the clock are four **clock gadgets**. These are used to control the clock functions of starting, stopping and resetting the clock, as well as getting help or quitting the present experiment.

The hands of the clock **icon** do not move. Instead, the elapsed time appears as a digital value in the value bar. The units of time are normally minutes and seconds, abbreviated mm:ss. Other units are available, such as seconds and tenths of seconds, ss.t, and hours and minutes, hh:mm.


THE PHYSICAL SCIENCE LABORATORY

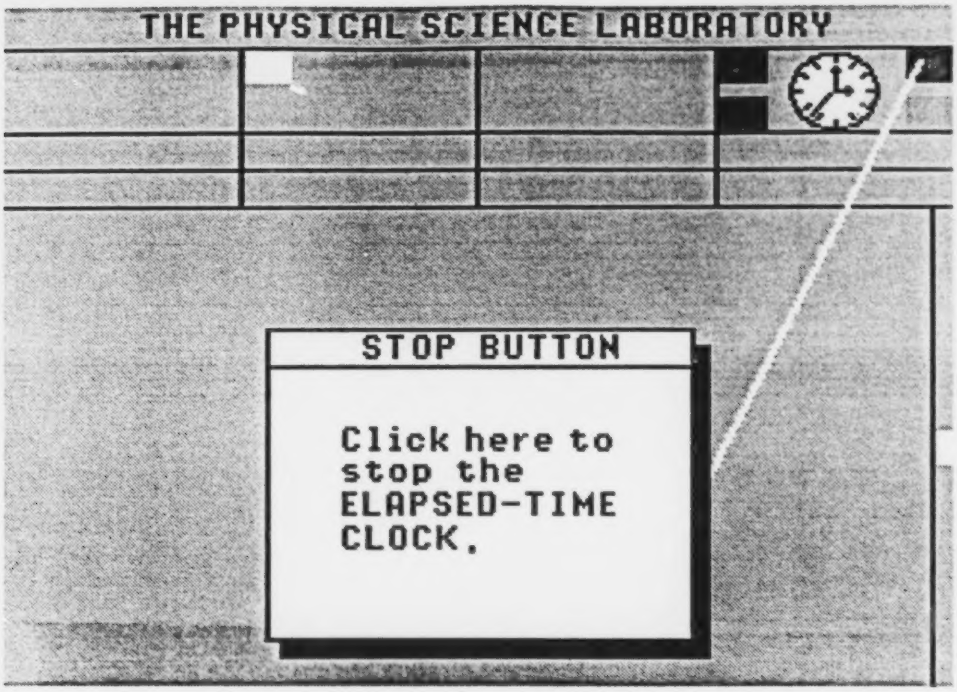
START BUTTON

Click here to start the ELAPSED-TIME CLOCK.

**Experiment 0: The Physical Science Laboratory**
**Figure 10: The Elapsed-Time Clock Start Button**

The green gadget in the upper left-hand corner of the clock shelf is called the **start button**. Clicking on the start button will start the clock. The clock functions like a stop watch with one important difference. **Experimental activity is controlled by the clock.** Whenever the clock is stopped, all experimental activity ceases, i.e., time does not advance for the simulated event on the lab bench. Whenever the clock is started, time advances and the simulated event proceeds. Clicking on the start button while time is advancing has no effect.

**It is important to note** that the function of starting or stopping the clock is performed only when the mouse button is released, not when it is first depressed. Do not hold the button down for any longer than necessary. Click quickly!



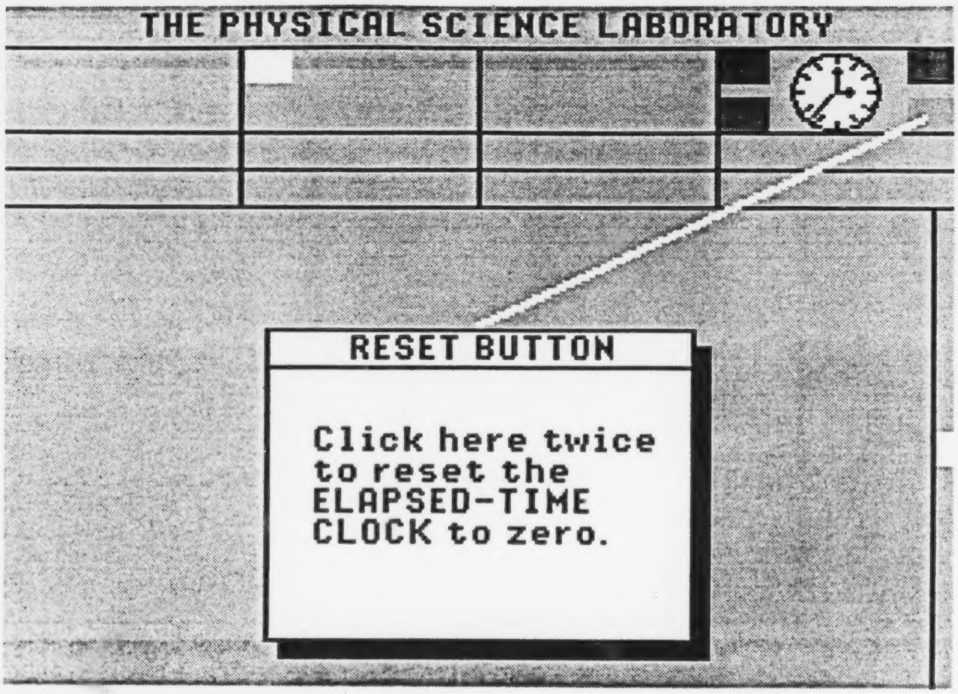
STOP BUTTON

Click here to stop the ELAPSED-TIME CLOCK.

**Experiment 0: The Physical Science Laboratory**
**Figure 11: The Elapsed-Time Clock Stop Button**

The red gadget in the upper right-hand corner of the clock shelf is called the **stop button**. Clicking on the stop button will stop the clock. All experimental activity ceases when the clock is stopped. Time does not advance. Stopping the clock during an experiment freezes the system in its current state. It is still possible, however, to take measurements and read the results for that moment in time.

Some experimental parameters can be changed while the clock is stopped. These will not take effect until the clock is restarted. For example, experimental objects that are influenced by gravitational force can be positioned in space while the clock is stopped, and will not move until the clock is started.

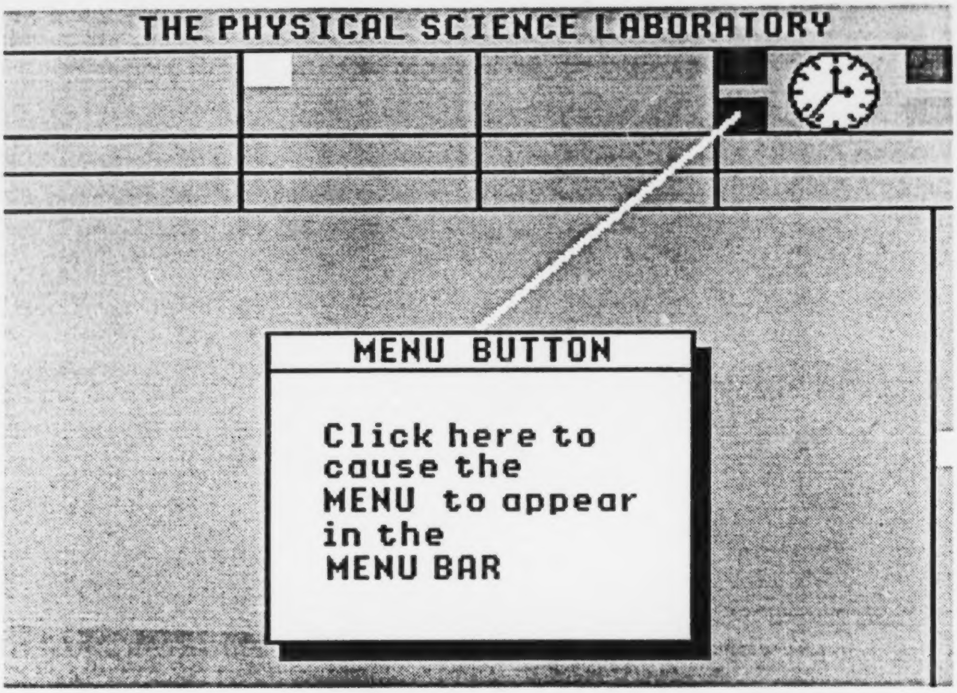


Click here twice to reset the ELAPSED-TIME CLOCK to zero.

**Experiment 0: The Physical Science Laboratory**
**Figure 12: The Elapsed-Time Clock Reset Button**

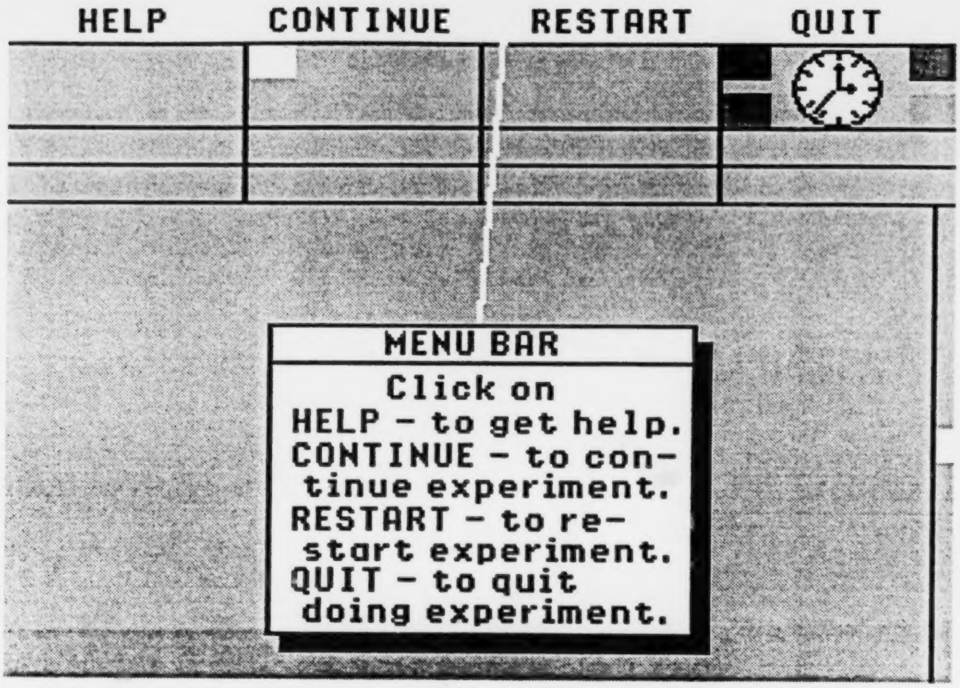
The yellow gadget in the lower right-hand corner of the clock shelf is known as the **reset button**. Clicking once on the reset button causes the clock to stop and the message **reset?** to appear in the clock units bar. Clicking once again on the reset button causes the clock, itself, to reset to the zero state. Time in the value bar will return to 00:00 if the units are minutes and seconds.

Experimental activity ceases when the reset button is clicked on for the first time. The system behaves as if the **stop button** were pressed. Clicking on the **start button** will cancel the reset request and start the clock and experiment from where they left off.


THE PHYSICAL SCIENCE LABORATORY
MENU BUTTON
Click here to cause the MENU to appear in the MENU BAR

**Experiment 0: The Physical Science Laboratory**
**Figure 13: The Elapsed-Time Clock Menu Button**

The blue gadget in the lower left-hand corner of the clock shelf is called the **menu button** or **menu gadget**. Clicking on the menu gadget will cause a menu to appear near the top line of the computer screen. Clicking on the menu gadget has the same effect on the experiment as clicking on the **stop button**.

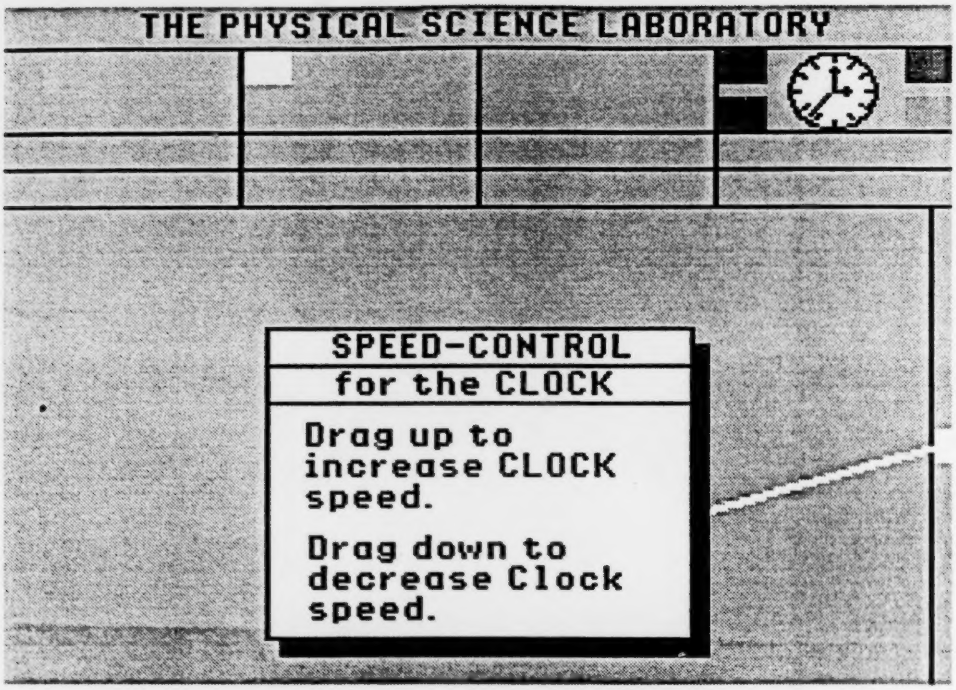


Click on
HELP - to get help.
CONTINUE - to continue experiment.
RESTART - to restart experiment.
QUIT - to quit doing experiment.

**Experiment 0: The Physical Science Laboratory**
**Figure 14: The Menu Bar**

The **menu bar** is the text line that appears at the top of the computer screen. Normally, the title of the current experiment appears in the menu bar. Clicking on the **menu button** in the clock shelf causes a menu to be displayed in the menu bar.

Four options are available by clicking on the appropriate word in the menu bar. Clicking on the word **HELP** will highlight the word HELP, itself. Now the user may point and click to locations on the screen to see and hear help messages associated with those locations. Clicking on the word **CONTINUE** returns the laboratory to its current state with the clock stopped. Clicking on the word **RESTART** will restart the experiment from scratch. And clicking on the word **QUIT** will return the user to the operating system.



SPEED-CONTROL
for the CLOCK

Drag up to increase CLOCK speed.

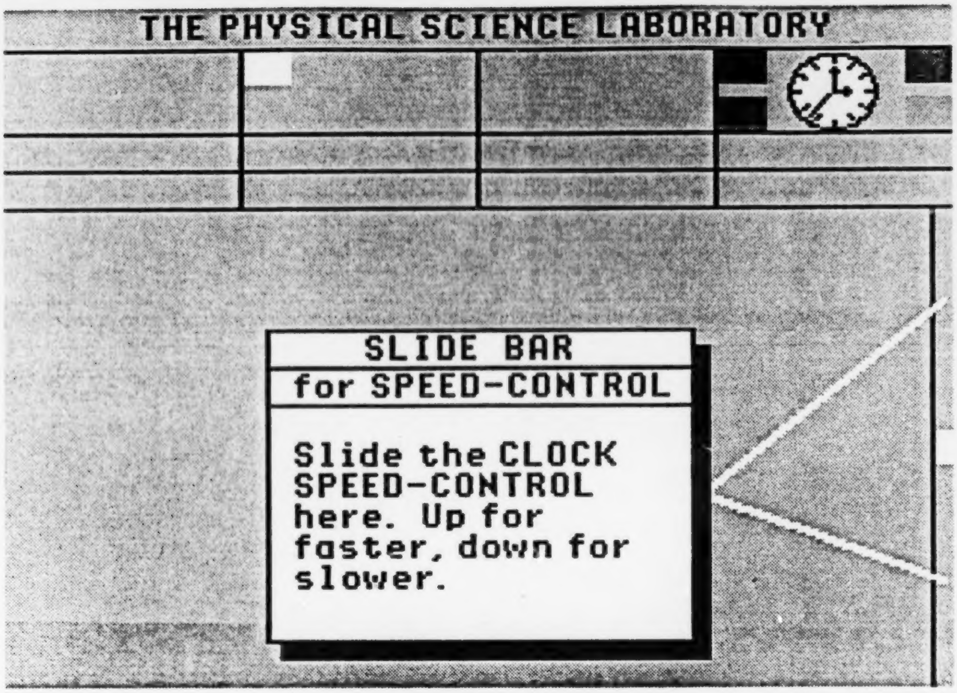
Drag down to decrease Clock speed.

**Experiment 0: The Physical Science Laboratory**
**Figure 15: The Speed-Control For The Clock**

On the right-hand side of the screen is a long, vertically-oriented rectangle that provides the boundaries for a smaller, white rectangle called the **speed-control** for the clock. The rate at which time advances relative to a real-world clock is controlled by the position of the clock speed-control.

When the **elapsed-time clock** is stopped, dragging it upwards causes time in the Physical Science Laboratory to advance more quickly; dragging it downwards causes time to advance more slowly. The relative speed of the clock can be read in the clock value bar while changing the position of the clock speed-control. During the change the word "speed" appears in the clock units bar.

When the elapsed-time clock is running, the relative speed of the clock can be seen momentarily by clicking on the clock speed-control.



THE PHYSICAL SCIENCE LABORATORY

SLIDE BAR
for SPEED-CONTROL

Slide the CLOCK SPEED-CONTROL here. Up for faster, down for slower.

**Experiment 0: The Physical Science Laboratory**
**Figure 16: The Slide Bar For The Clock Speed-Control**

The **slide bar** for the clock **speed-control** is the long, vertically-oriented rectangle on the right-hand side of the computer screen. The slide bar provides the boundaries for the clock speed-control while the speed control is being repositioned.

As mentioned elsewhere, the speed-control can be repositioned by the user when the clock is stopped. It can also be repositioned by the simulation program! When the clock is running, and simulated events are taking longer to run on the computer than the desired relative speed - as previously set by positioning the speed control - the simulation program will move the speed control downwards to indicate the actual relative speed at which events are being displayed.

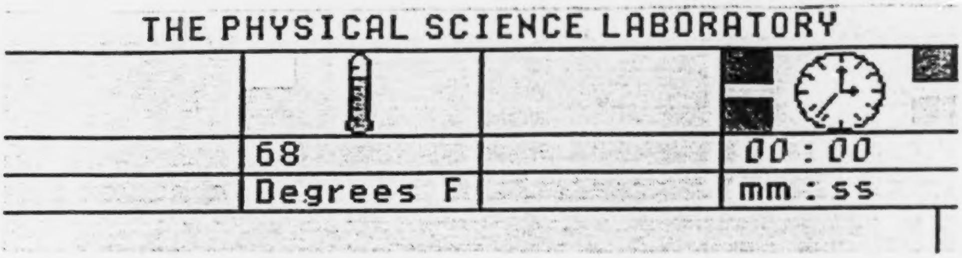
## More About The Elapsed-Time Clock: Technical Notes

The elapsed-time clock in the Physical Science Laboratory is designed to mimic the behavior of a a real-world clock. More importantly, however, it is designed to keep track of time as it advances during a given simulation.

It is quite possible to require more time to compute and display the events taking place on the computer screen, than it would actually take for the events to occur in real time. In this case, the simulation time - as displayed by the elapsed-time clock - will fall behind real time. When this happens, events occurring on the computer screen will appear to be moving more slowly than they would in the real world. However, because the clock and events move together in the Physical Science Laboratory, measurements will still show the same time-dependent behavor as the real-world measurements they are attempting to duplicate. As computer hardware and computational algorithms get faster, real-time simulation of complex events will get closer to reality.

When the simulation program can display results and compute its next state faster than real-time events, it waits until real time can catch up before it continues its cycle. If simulation time falls behind real time, the simulation program trys to catch up by running as fast as it possibly can. Events such as voicing measurements while the clock is running tend to slow down the simulation. As simulation time falls behind, the program computes how fast the the elapsed-time clock is running relative to real time and displays the results by repositioning the clock speed control.

Suggestion: if simulation time falls behind, and you want to keep as close to a real-time display as possible, you can speed things up by displaying time in hours and minutes, and by turning off any changing value displays by clicking on the value bars. If possible, remove unnecessary instruments from the lab bench that are doing continuous monitoring.


THE PHYSICAL SCIENCE LABORATORY

68

Degrees F

00 : 00

mm : ss

**Experiment 0: The Physical Science Laboratory**
**Figure 17: An Example - The Thermometer Instrument**

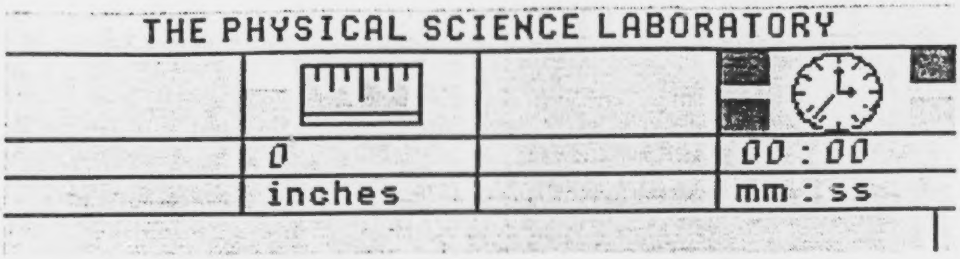
The **thermometer instrument** enables the user to measure temperatures on the lab bench. The thermometer instrument, as depicted, is merely an **icon.** It is not meant to look realistic, but merely resemble a thermometer. As drawn, the thermometer instrument measures the temperature of objects and locations directly under its bulb - the lower, rounded end.

The thermometer instrument used in the laboratory experiments is truly remarkable: it will not break if you drop it; it is always accurate; it is unaffected by extreme heat and pressure; it measures temperatures instantaneously; and its range is from absolute zero to the highest temperatures known to mankind. Of course, real thermometers have real limitations and these will be discovered as we pursue the experiments in this series.

To use the thermometer drag it from its location on the shelf and release it over the object or location on the lab bench that needs to be measured. While located on the lab bench the thermometer will continuously monitor the temperature and display the value in the value bar of the thermometer instrument window.

The units of measure are normally Celsius or Fahrenheit degrees. The current units are displayed in the units bar and can be changed by clicking on the units bar, itself.

The Physical Science Laboratory proper is maintained by its owners at a comfortable 68 degrees Fahrenheit (20 degrees Celsius). Thermometers residing on the instrument shelf or the unadorned lab bench will measure this temperature. The degree of precision to which the thermometer displays a measurement is somewhat dependent on the experiment. In the early experiments temperature is usually rounded to the nearest degree.



**Experiment 0: The Physical Science Laboratory**
**Figure 18: Another Example - The Ruler Instrument**

The **ruler instrument** enables the user to measure length directly on the lab bench. The ruler instrument, as depicted, is merely an **icon.** It is not intended to look realistic, that is, its scale is representational only.

The ruler instrument works by having the simulation program note the ruler's initial position and final position as specified by the user, and then take the difference between these two points. Since the motion is strictly translational, **all points on the ruler move the same distance.**

The designers of this instrument have selected the upper-left corner of this icon as a reference point from which to draw a line indicating the distance between the initial and final positions. The length of this line is always equal to the distance between these two points. The first-time user will probably want to use the upper-left corner when doing measurements, but should not feel constrained to use only this location.

To use the ruler: drag it to its starting location; release it to mark the initial position; move it to its final position, and click the mouse to mark the final position. The distance will be displayed in the value bar and the units in the units bar. The units can be changed to a variety of measures by clicking on the units bar. The distance measured will most often depend on the experiment. In some cases it may be no longer than the actual computer screen dimensions; in others, it may be orders of magnitude larger.

Return the ruler to its shelf location by dragging it there. It will only go on the shelf from whence it came.

# Worksheet 0-1: Touring The Physical Science Lab

Name: ______________________________ Date: __________

Teacher: ______________________________________________

Class: ______________________________ Score: __________

## What You Should Already Know

If you are going to be using a mouse for the first time, we suggest that you watch the video called **Using A Mouse** that comes with the Teacher's Manual. Another video, **Touring The Lab**, is available to introduce you to the basic features of the Physical Science Laboratory. We urge you to watch both of these videos before you begin this experiment.

You should know the meaning of certain words that are used to describe what to do with the mouse, as you work in the Physical Science Laboratory. Check off the words for which you know the meaning. Look up the definitions of the words that you don't know in the **Glossary** on page 4 of this Activity Worksheet.

**Mouse** __________
**Mouse Pointer** __________
**Icon** __________
**Click** __________
**Click On** __________
**Double Click** __________
**Press** __________
**Release** __________
**Drag** __________
**Gadget** __________
**Select** __________
**Choose** __________

**Problem 1 - Getting To Know The Physical Science Laboratory**

Make yourself at home in the laboratory by finding out exactly where things are and what they are called. Follow the instructions below to learn the names of the places in the lab. As you learn the names, write them on the picture of the lab that you will find on page 5 of this Activity Worksheet.

**Instructions For Problem 1**

1) Have your teacher help you get started with loading and running the disk called "Experiment 0".

2) When the picture of the Physical Science Laboratory appears on the computer screen, move the mouse pointer over the blue rectangle. Click on the blue rectangle. Four words will appear at the top of the computer screen: HELP CONTINUE RESTART QUIT. Taken as a group, these words are called a **menu** and appear in the **menu bar**.

3) Click on the word HELP in the menu bar. The word HELP will change colors when you click on it. This shows that you are in the HELP mode. A help window will pop up in the middle of the screen.

4) Select (click on) the CONTINUE word in the menu bar. The help window will disappear. **Note: Whenever a help window is on the screen you must select the CONTINUE word before the program will respond to your next command.**

5) Move the mouse pointer to the middle of the computer screen and click the mouse. Another help window will appear in the middle of the computer screen. At the top of the help window you will find the name of the place or object on which you just clicked. Write the name of this place on the picture of the lab that you will find on page 5 of this Worksheet.

6) Select the CONTINUE word again. Click on another place or thing in the Physical Science Laboratory. Write the name of the new place or thing on the picture of the lab. Continue to click until you have written down the names aces and things that you can find in the lab. Don't forget to select the CONTINUE word before you try to click on something new.

When you want to stop getting help, select the CONTINUE word twice. The menu bar will change to the words "THE PHYSICAL SCIENCE LABORATORY" and you can operate things in the lab normally again.

**Problem 2 - How to Quit**

Quit doing this experiment altogether and use the computer for something else.

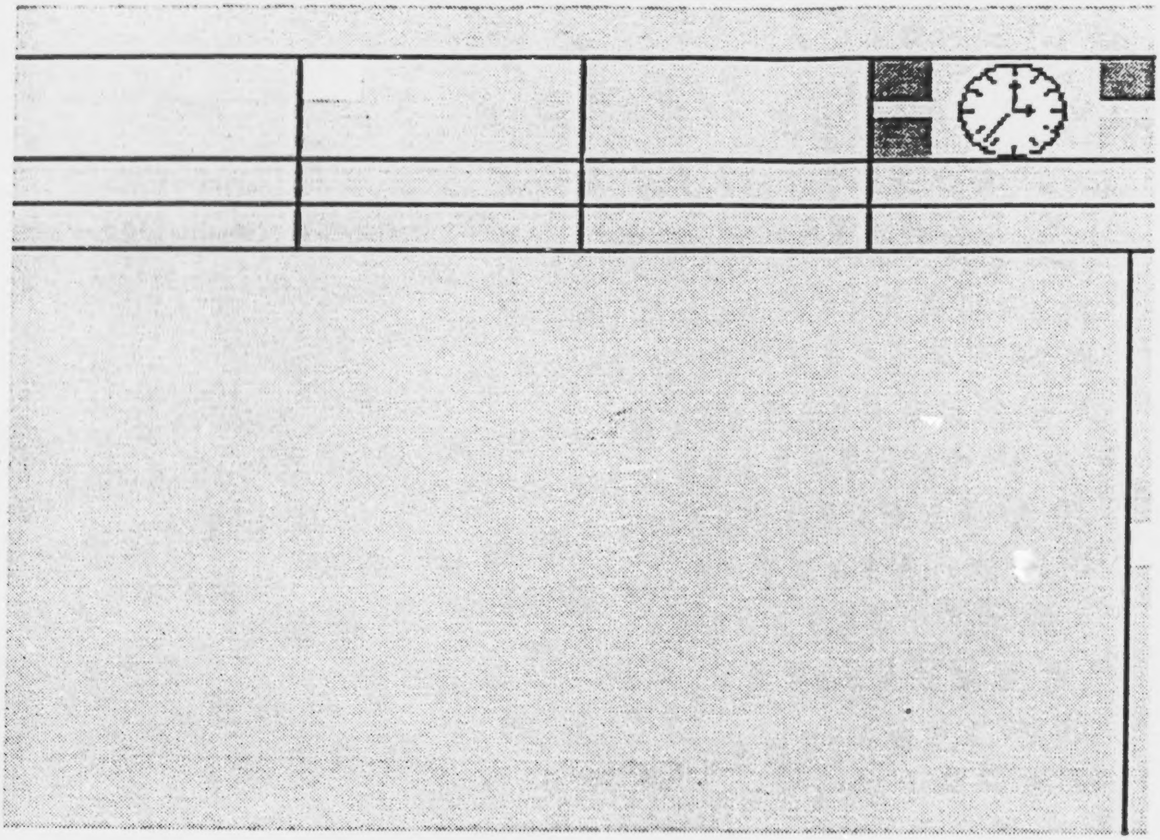
**Instructions For Problem 2**

Click on the blue rectangle. You may know it now as the **menu gadget**. The menu will appear again at the top of the screen. Click on the word QUIT. The Physical Science Laboratory will disappear and you will be brought back to your operating system.

| **GLOSSARY** | **NOTE: Please read from top to bottom** |
|---|---|
| **Mouse** | An instrument that you hold in your hand and roll around on your desk top. It may have one or more buttons on top and is connected to your computer by a wire. Signals are sent to your computer from the mouse by pressing one of the buttons. When you move the mouse you can make a small picture on the computer screen move at the same time. |
| **Mouse Pointer** | An arrow or other pointy picture that moves across the computer screen when you move the mouse. |
| **Icon** | A small picture on the computer screen that looks like something you know. Sometimes you can make it move by using the mouse. |
| **Click** | (A mouse button) Tap one of the buttons - usually the button on the left if there are more than one - with your finger and make it go "click." |
| **Click On** | (Something on the computer screen) Move the pointy end of the mouse pointer over the place or thing on the computer screen and click. |
| **Double Click** | (A mouse button) Two quick clicks. Not used during these experiments except to start the program. |
| **Press** | (A mouse button) Push the mouse button down and hold it there. Don't let up until told. |
| **Release** | (A mouse button) Stop pressing on the mouse button. Release is the opposite of press. |
| **Drag** | (An icon) Move the mouse pointer over the icon. Press. While still pressing move the mouse and the icon to the place on the computer screen where you want it to go. Release. |
| **Gadget** | A place on the screen that if you click on it something will happen. Gadgets are often small squares or rectangles. |
| **Select** | Click on a gadget or some other object. |
| **Choose** | Same as select. |

**INSTRUCTIONS:**

Please write in the names of the places and things you can identify in the Physical Science Laboratory. Use the white space around the picture when the names will not fit in the picture.



5 of 5

## Worksheet 0-2: Using The Instruments

Name: ______________________ Date: __________

Teacher: ______________________________

Class: ______________________ Score: __________

### Problem 1 - Using The Next Gadget

Use the **next gadget** to discover how many and what kind of instruments are currently on the instrument shelf in the second instrument window. Write the names of the instruments in the answer box below.

**Answer 1**

### Instructions For Problem 1

The next gadget is the small white rectangle that appears in the second instrument window near the top of the computer screen. Click on the next gadget to cause the "next" instrument on the instrument shelf to appear. Keep clicking until you have seen all the instruments that have been placed on this shelf for this experiment.

### Problem 2 - Using The Thermometer Instrument

Use the thermometer instrument to determine the temperature of the lab bench. Record your findings in the answer box below.

**Answer 2**

**Instructions For Problem 2**

Click on the next gadget until the thermometer icon appears on the instrument shelf. Drag the thermometer instrument to the lab bench and release it there. (Note: To drag the thermometer -move the pointer over the thermometer, press the mouse button down and hold it down while moving the mouse, release the mouse button when the thermometer is located where you want it.)

When you release the thermometer the computer will speak the current temperature and the numeric value of the temperature will appear in the value bar. However, if the number in the value bar is hidden, the voice will remain silent. Click once on the value bar to get the number to reappear and the computer to speak. Click on the value bar again to hide the number and silence the computer.

**Problem 3 - Changing The Units Of Measurement**

Determine the temperature of the lab bench in degrees Celsius as well as degrees Fahrenheit. Write your answer in the answer box below.

**Answer 3**

**Instructions For Problem 3**

Click on the units bar in the thermometer instrument window.

## Worksheet 0-3: Using Other Instruments

Name:________________________ Date:__________

Teacher:________________________________________

Class:________________________ Score:__________

### Problem 1: Using The Ruler Instrument

There are four steps to making a measurement with the ruler instrument. You can try to figure them out yourself, or read them in the instructions below.

### Instructions For Problem 1

1) Click the next gadget until the ruler appears on the instrument shelf. The value bar should read 0. Drag the ruler to the lab bench being careful not to release the mouse button.

   **Note: If you accidentally release the button while you are dragging it, simply click the mouse button once and then you will be able to drag the ruler instrument again.**

2) Drag the ruler to the left side of the lab bench - that's the side nearest instrument window number 1. Now you are ready to begin a measurement.

3) Release the button and move the ruler across the lab bench - toward your right.

   Notice the straight line that is drawn on the lab bench as you move the ruler. One end of the line is fixed at the point where you started your measurement. The other end extends from the upper-left corner of your ruler.

   The length of this line is always equal to the length of your measurement. This length can be read in the value bar of the ruler instrument window as you move the ruler.

4) To finish making a measurement simply click the mouse button once. The ruler will no longer move and the pointer will reappear on the screen.

You can now move the pointer wherever you want. To put the ruler back on the shelf you can either drag it there or click on the next gadget. Try using the ruler until you feel comfortable with the way it works.

Remember these four easy steps:

1) Drag the ruler to the starting point.
2) Release the mouse button to start the measurement.
3) Move the ruler to the stopping point.
4) Click the mouse button to end the measurment.

**Problem 2: Changing the units of length**

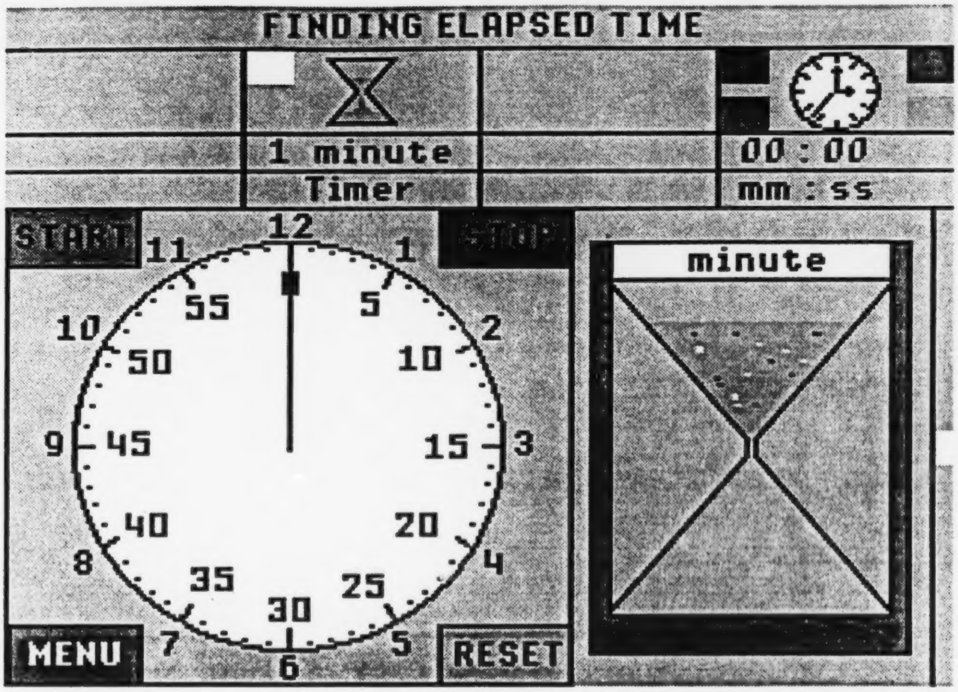
What are the different units of length that you can use for the ruler instrument? Make a simple length measurement on the lab bench. Find the length for each of the units that you wrote down.

**Answer 2**

**Instructions For Problem 2**

Clicking on the units bar in the ruler instrument window will change the units of measure for the ruler, and also give the corresponding length for that unit in the value bar.

# Introduction to Experiment 1:
# Finding Elapsed Time


FINDING ELAPSED TIME
1 minute
Timer
00 : 00
mm : ss
START
STOP
MENU
RESET
minute
12
1
2
3
4
5
6
7
8
9
10
11
5
10
15
20
25
30
35
40
45
50
55

**Experiment 1: Elapsed Time**
**Large Clock And 1 Minute Timer At The Start**

## Objectives

This environment is designed to help students learn how to use the elapsed-time clock in the Physical Science Laboratory. In addition, it can help students learn to read the time associated with the positions of the hands on the face of the elapsed-time clock.

## Features

### A large clock:

This environment features a large clock on the lab bench. The clock can be started, stopped and reset by clicking on one of the appropriate gadgets surrounding the large clock, or by clicking on one of the **clock gadgets** in the **clock instrument window**.

The units of time being displayed in the clock **value bar** can be changed by clicking on the **units bar** of the clock instrument window. Possible units include hours and minutes (abbreviated hh:mm), minutes and seconds (abbreviated mm:ss), seconds and tenths of seconds (abbreviated ss.t). When different units are selected the hands on the large clock will change to display the units selected. The large clock has three different sets of hands. One set displays hours and minutes; another set displays minutes and seconds, and a third set displays just seconds.

If you click on the clock value bar when the time is hidden, the computer will speak the time as the value reappears. If the value is being displayed, click on the value bar twice in order to hear the voice. The elapsed time will be given in the units displayed in the clock units bar.

### Sand-in-glass timers:

If the clock is reset to its zero state, a **next gadget** appears in the second instrument window. By clicking on the next gadget, when the hour-glass icon appears in the window, it is possible to select one of three different sand-in-glass timers for keeping track of time. A minute, second, and hour timer are available. A fourth click on the same next gadget will leave the lab bench free of timers. The cycle may be repeated as often as desired. Once the clock has been started, however, the next gadget disappears and no further selections are possible until the clock is reset.

## Worksheet 1-1: Using The Elapsed-Time Clock

Name:______________________ Date:__________

Teacher:______________________________

Class:______________________ Score:__________

**Problem 1 - Measuring Time**

Put the **1 minute Timer** on the lab bench. Use the clock to measure how long it takes the sand in the Timer to fall from the top to the bottom. Write your measurement in the box below.

**Answer 1**

### Instructions For Problem 1

The clock in the Physical Science Laboratory can be used to measure how long it takes something to happen. For this reason it is called an elapsed-time clock. It acts just like a stop watch: you can start it, stop it, and reset it to zero.

You will find some timers on the shelf in instrument window 2. Clicking on the next gadget will let you select the one you want. Start the clock: use the START button on the lab bench or the start button in the clock window. Stop the clock when all the sand has fallen to the bottom: use the STOP button on the lab bench or in the clock window.

You may have noticed that the sand began falling as soon as you started the clock. That's because the elapsed-time clock in this laboratory is special; it actually controls time. With it you can stop time and start it up again whenever you want.

**Problem 2 - Stopping Time!**

Make sure that the 1 minute Timer is on the lab bench. Use the elapsed-time clock to start and stop the flow of time in the Physical Science Laboratory. How can you tell that time has stopped and not just the clock?

**Answer 2**

**Instructions For Problem 2**

Reset the clock to 00:00; you do this by clicking on the RESET button twice. Make sure that the 1 minute Timer is on the lab bench. START the clock. After 20 seconds have gone by (elapsed), STOP the clock. Once the clock has stopped, observe what is or is not happening in the lab.

**Problem 3 - Telling Time**

Get the clock to tell you how much time has elapsed. It will actually speak the time in a slightly accented voice. Explain how you got the clock to tell.

**Answer 3**

**Instructions For Problem 3**

Stop the clock. You can see how much time has gone by since you first started the clock by reading the minutes and seconds from the value bar of the clock, or by looking at the hands on the large clock. Now click on the value bar of the clock: the number will disappear. Click on the value bar of the clock again.

## Worksheet 1-2: Making Time Go Faster Or Slower

Name:________________________ Date:__________

Teacher:________________________________________

Class:________________________ Score:__________

### Problem 1 - Making Time Go Faster

Normally, it takes exactly 1 minute for the sand in a 1 minute timer to flow from the top to the bottom. Make the sand in the 1 minute Timer in the Physical Science Laboratory flow faster so that it takes less than 1 minute for the sand to move from top to bottom. If you can do it, how do you know that it is taking less than a full minute?

**Answer 1**

### Instructions For Problem 1

Click on the RESET button until the next gadget appears in one of the instrument windows. Click on the next gadget until the 1 minute Timer appears on the lab bench. Ordinarily, it would take one minute for the sand to empty out of the top of the Timer once you started the elapsed-time clock. Before starting the clock, however, drag the clock speed-control as high as you can in the slide bar. (Note: The clock speed control is the small white rectangle on the right-hand side of the laboratory.) Start the elapsed-time clock.

**Problem 2 - Making Time Go More Slowly**

Place the 1 second Timer on the lab bench. Make the sand flow to the bottom in more than 1 second. How do you know that it is taking more than 1 second for this to happen? Can you tell how long it actually takes?

**Answer 2**

**Instructions For Problem 2**

Click on the RESET button to display the next gadget in one of the instrument windows. Click on the next gadget until the 1 second Timer appears. Slide the clock speed-control all the way to the bottom of the slide bar. Start the elapsed time clock.

**Problem 3 - Counting Out A Minute**

Without watching the seconds tick off on a clock, start at the number 1 and count (1, 2, 3...) until exactly 1 minute goes by. What number did you reach when the minute was up? Do it a second time. What number did you reach on the second try? How different are the two numbers? Do you think that you have some sort of a clock inside your body?

**Answer 3**

**Instructions For Problem 3**

You can use the elapsed-time clock for this experiment. Move the speed-control to the normal postion (it should completely cover the black rectangle). Click on the clock RESET button until the next gadget appears. Click on the next gadget until there are no timers on the lab bench. Set the clock units to hours and minutes (hh:mm) by clicking on the clock units bar. Start the clock and start counting. When the time changes from 00:00 to 00:01 in the value bar stop counting. Write down the number you reach.

## Worksheet 1-3: Time Sense

The activities on this worksheet were suggested by the autobiography of Richard Feynman, physicist (1).

Name:______________________________ Date:__________

Teacher:____________________________________________

Class:_____________________________ Score:_________

### Problem 1: Speeding Up Your Internal Clock?

Does your sense of time change when your body is moving faster? Try counting until 1 minute goes by while you are walking quickly in place (While standing, lift your legs up and down, but don't actually walk forward). Write down the number you reach. Do it a second time. Record the number.

**Answer 1**

### Instructions For Problem 1

Use the elapsed-time clock to keep track of time. Make sure the clock is running at normal speed. Put the clock in the hours and minutes mode so that you can't see the seconds tick by.

### Problem 2: Slowing Down Your Internal Clock

Does your sense of time change when your body is moving more slowly? Try counting until 1 minute goes by while you are resting comfortably in a chair or on the floor. Have someone tell you when a minute is up if necessary. Write down the number you reach. Do it again. Write down the second number.

**Answer 2**

### Instructions For Problem 2

Follow the instructions for Problem 1.

**Problem 3: Comparing The Results**

Find the average of the two sets of numbers. Are they different? How much different?

**Answer 3**

### Instructions For Problem 3

To find the average of two numbers add them up and divide by 2.

For example, suppose the two numbers were 87 and 92. First add 87 and 92.

$$87 + 92 = 179$$

Then divide 179 by 2.

$$\frac{179}{2} = 89.5$$

The average is 89.5.

Compute the averages for Problem 1 and Problem 2. Then compare the two averages. Which is bigger or are they about the same?

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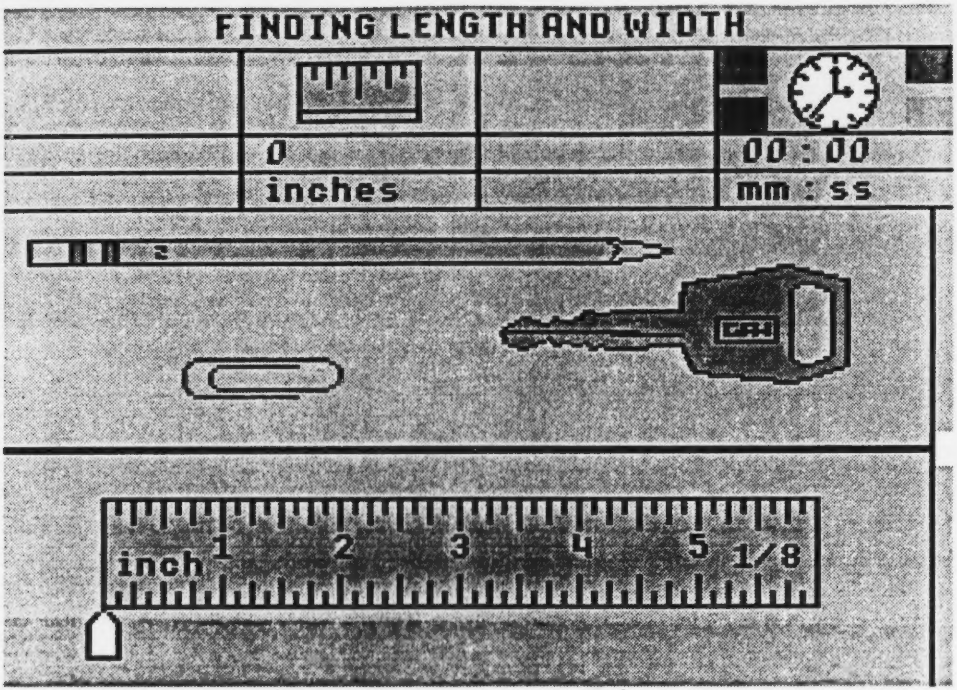
1. For more information see "What Do You Care What Other People Think? - Further Adventures Of A Curious Character", by Richard P. Feynam, as told to Ralph Leighton, pp. 55-59, Norton, 1988.

## Introduction to Experiment 2:
## Finding Length and Width


FINDING LENGTH AND WIDTH
0
inches
00 : 00
mm : ss
inch
1
2
3
4
5
1/8

**Experiment 2: Finding Length And Width**
**Starting Screen, Ruler With 1/8 Inch Divisions**

## Objectives

This environment is designed to help students learn how to read the scales associated with a ruler, as well as learn how to use the ruler instrument of the Physical Science Laboratory. Several different scales are available that show units of inches, millimeters, or centimeters.

## Features

### General Description:

The ruler instrument is used to make length measurements of the objects located on the lab bench. As the student makes the measurements, the distance being measured is displayed in the value bar of the ruler instrument. At the same time a pointer points out the distance on a full-sized ruler shown on the screen. The student may choose to show or hide the number displayed in the value bar. If the value bar is not hidden when the measurement is completed, the measurement will be spoken by the computer.

Learning to read the different scales of a ruler is a matter of making a length measurement, looking at the ruler scale, and interpreting the results. The program provides constant feedback to the student by pointing out the scale value while simultaneously displaying the corresponding numerical value. Additional reinforcement is accomplished through the use of voice synthesis.

### The Ruler Instrument:

The ruler instrument appears on the shelf in instrument window two at the start of the experiment. A length measurement is made with the ruler by using it to identify the beginning and ending point of a measurement.

Positioning the ruler to begin a Measurement

Drag the ruler to its starting location. (Move the mouse pointer over the ruler and press the mouse button. While pressing the mouse button, move the mouse - and consequently the ruler - to the desired starting location.)

Beginning the measurement

Release the mouse button. (After dragging the ruler to the starting location, let up on the mouse button.)

When making horizontal measurements you can align the left edge of the ruler with the starting location on the object being measured. When making vertical measurements you can use the top edge of the ruler. See what happens when you start from other locations on the ruler.

Marking off the distance

Move the mouse to the ending location. A line will be drawn on the screen as you move the mouse. The length of that line is the current distance you will have moved from the beginning position.

Ending the measurement

Click when you have reached the ending location. (Press and release the mouse button quickly.)

The mouse pointer will reappear. You are free to display the measurement in different units at this time. If the value bar is not hidden the computer will also "speak" the number shown in the value bar. The measurement is the length of the colored line that has been drawn on the screen.

**The Large Ruler:**

The large ruler appears in the lower half of the computer screen. The scale on the large ruler corresponds to the units appearing in the units bar of the ruler instrument window. The units of measurement and, correspondingly, the scale on the large ruler can be changed by clicking on the units bar, itself.

Four different units of measurement are available.

inches by 1/8 inch divisions - distance is reported to the nearest 1/16 inch.

inches by 1/10 inch divisions - distance is reported to the nearest 0.05 inches.

centimeters by 1/2 centimeter divisions - distance is reported to the nearest 0.1 centimeters.

millimeters by 5 millimeter divisions - distance is reported to the nearest millimeter.

## Worksheet 2-1: Using The Ruler

Name:____________________________________ Date:____________

Teacher:____________________________________________________

Class:____________________________________ Score:____________

**Problem 1: Learn How To Use The Ruler To Measure Length**

Learn how to use the ruler to measure the length of the pencil by carefully following the instructions below.

### Instructions For Problem 1

1) Make sure the value bar in the ruler instrument window is not hidden. If it is hidden by a white bar, click on it to make it appear.

2) Look at the large ruler at the bottom of the lab bench. The word **inch** should appear on one side of the ruler and the fraction **1/8** should appear on the other. Click on the units bar in the ruler instrument window until they do.

3) Move the pointer over the ruler instrument. You will normally find the ruler instrument on the shelf in the ruler instrument window.

4) Drag the ruler instrument from the shelf and line up the left edge of the ruler instrument with the left edge of the eraser on the pencil. When the edges are lined up release the mouse button.

5) Move the ruler instrument across the lab bench until the left edge of the ruler is lined up with the very tip of the pencil.

6) Now click the mouse. The distance you measured will appear in the value bar, and the computer will speak the measurement.

You should have measured 5 and 7/16 inches. As you are making a measurement a line is drawn on the lab bench from the point where you start to the point where you stop. The length of this colored line is always the same as the length of your measurement.

**Remember these steps to make it easy to use the ruler:**

1) Drag the ruler to the starting point.

2) Release the mouse button to start the measurement.

3) Move the ruler to the stopping point.

4) Click the mouse button to end the measurement. Your pointer will reappear. If the value bar is not hidden, the final measurement will be displayed in the value bar, and the computer will speak the measurement.

**Problem 2: Measure The Length Of The Paperclip**

What is the length of the paperclip? Measure across the lab bench, not up and down.

**Answer 2**

## Worksheet 2-2: More Ruler Measurements

Name:______________________________ Date:__________

Teacher:______________________________________________

Class:______________________________ Score:__________

**Problem 1: Measuring Width**

Measure the width of the pencil and the width of the paperclip. Make sure the large ruler with the fraction 1/8 printed on it is present on the lab bench.

**Answer 1**

### Instructions For Problem 1

First, remember the four easy steps for using the ruler.

1) Drag the ruler to the starting point.
2) Release the mouse button to start the measurement.
3) Move the ruler to the stopping point.
4) Click the mouse button to end the measurement.

To measure the width of the pencil, use the top edge of the ruler.

1) Drag the ruler until the top edge of the ruler lines up with the top edge of the pencil.
2) Release the mouse button.
3) Move the ruler instrument straight down until the top edge of the ruler lines up with the bottom edge of the pencil.
4) Click the mouse button. Read the width in the value bar.

Follow the same steps to measure the width of the paperclip.

**Problem 2: Measuring Diagonally**

Measure the distance from the upper left corner of the lab bench to the tip of the key.

**Answer 2**

**Instructions For Problem 2**

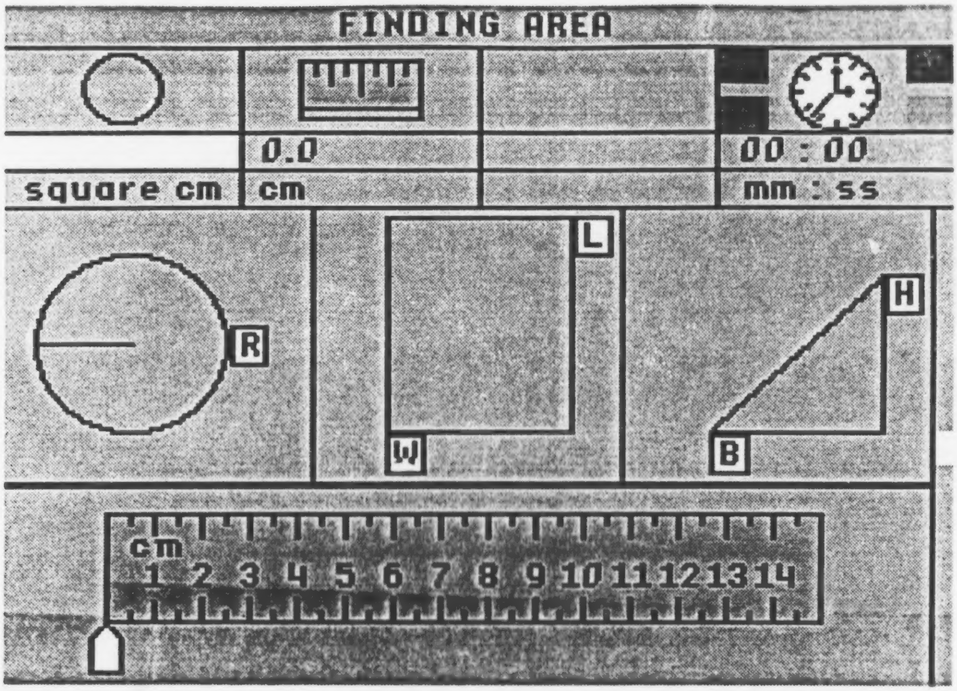
You can use the ruler instrument to make diagonal measurements as well. Use the upper left corner of the ruler while making your measurements.

To measure the distance from the upper left corner of the lab bench to the tip of the key:

1) Drag the ruler until the upper left corner of the ruler is in the upper left corner of the lab bench.
2) Release the mouse button when the ruler is in the corner.
3) Move the ruler so that its upper left corner just touches the tip of the key.
4) Click the mouse button and read the measurement in the value bar.

# Introduction to Experiment 3:

# Finding Area


FINDING AREA
0.0
00 : 00
square cm
cm
mm : ss
R
L
W
H
B
cm
1 2 3 4 5 6 7 8 9 10 11 12 13 14

**Experiment 3: Finding Area**
**Circle Selected, Area Value Hidden, Centimeter Scale**

## Objectives

This environment is designed to help students learn how to read the scales associated with a ruler, while exploring the concept of area measurement.

## Features

### General Description:

The ruler instrument is used to make length measurements of the objects located on the lab bench. As the student makes the measurements, the distance being measured is displayed in the value bar of the ruler instrument. At the same time a pointer points out the distance on a full-sized ruler shown on the screen. The student may choose to show or hide the number displayed in the value bar. If the value bar is not hidden when the measurement is completed, the measurement will be spoken by the computer.

Three geometric figures appear on the lab bench along with the large ruler. The size of each geometric figure can be changed by dragging one of the sizing gadgets in the appropriate direction. For example, dragging the gadget labeled **W** to the left or right will cause the width of the rectangle to change. The area of the figure being manipulated also appears in the value bar of instrument window one. The picture on page 1 shows that the numerical value of the area has been hidden by the user.

### The Ruler Instrument:

The ruler instrument appears on the shelf in instrument window two at the start of the experiment. A length measurement is made with the ruler by using it to identify the beginning and ending point of a measurement.

Positioning the ruler to begin a Measurement

Drag the ruler to its starting location. (Move the mouse pointer over the ruler and press the mouse button. While pressing the mouse button, move the mouse - and consequently the ruler - to the desired starting location.)

Beginning the measurement

Release the mouse button. (After dragging the ruler to the starting location, let up on the mouse button.)

When making horizontal measurements you can align the left edge of the ruler with the starting location on the object being measured. When making vertical measurements you can use the top edge of the ruler. See what happens when you start from other locations on the ruler.

Marking off the distance

Move the mouse to the ending location. A line will be drawn on the screen as you move the mouse. The length of that line is the current distance you will have moved from the beginning position.

Ending the measurement

Click when you have reached the ending location. (Press and release the mouse button quickly.)

The mouse pointer will reappear. You are free to display the measurement in different units at this time. If the value bar is not hidden the computer will also "speak" the number shown in the value bar. The measurement is the length of the colored line that has been drawn on the screen.

### The Large Ruler:

The large ruler appears in the lower half of the computer screen. The scale on the large ruler corresponds to the units appearing in the units bar of the ruler instrument window. The units of measurement and, correspondingly, the scale on the large ruler can be changed by clicking on the units bar, itself.

Four different units of measurement are available.

inches by 1/8 inch divisions - distance is reported to the nearest 1/16 inch.

inches by 1/10 inch divisions - distance is reported to the nearest 0.05 inches.

centimeters by 1/2 centimeter divisions - distance is reported to the nearest 0.1 centimeters.

millimeters by 5 millimeter divisions - distance is reported to the nearest millimeter.

### The Geometric Figures:

Three geometric figures - a circle, a rectangle and a right triangle - appear on the lab bench. The size of these figures can be changed by moving the sizing gadgets associated with each figure.

## The Circle

Select the sizing gadget labeled **R** and drag it to the left or right to change the radius of the circle. Once selected, a circle will appear on the shelf in window one, and the area of the circle will be continuously displayed in the value bar. The units displayed in the value bar will be the same as those selected for the ruler instrument.

The area of the circle is computed from the radius shown with the circle. The radius includes the border or perimeter of the circle.

## The Rectangle

Select either the length or width sizing gadget ( **L** and **W**, respectively) to change the size of the rectangle. The area displayed includes the borders of the figure.

## The Right Triangle

Select either the height or base gadget (**H** or **B**) to change the size of the right triangle.

When measuring the length of the base, extend your measurement from the lower right corner of the triangle to the left edge of the base sizing gadget. When measuring the height, use the lower right corner and the top edge of the height sizing gadget. You will have to use the right edge of the ruler instrument to do these measurements.

## Worksheet 3-1: Area Of A Rectangle

Name:______________________________________ Date:_____________
Teacher:______________________________________________________
Class:______________________________________ Score:____________

### What You Should Already Know

You should know how to use the ruler instrument to measure the length and width of objects in the Physical Science Laboratory. If you are using the ruler for the first time, we suggest you try Experiment 2 before you do this one.

### Problem 1 - The Length of A Rectangle

First: Click on the value bar in instrument window number 1 - the instrument window that is furthest away from the elapsed-time clock. The value bar should turn completely white.

Then: Find the length of the largest rectangle that you can make on the lab bench.

### Answer 2

### Instructions For Problem 1

Before you start, check to see that the scale of the large ruler is showing inches with 1/10 inch divisions. The word **inch** and the fraction **1/10** will be printed on the large ruler at the bottom of the lab bench. The word **inches** will appear in the ruler units bar. Click on the units bar in the ruler instrument window to change the units if you need to.

The length of the rectangle is controlled by the length gadget. The length gadget has the letter **L** printed in the center. Drag the length gadget up and down to get a feeling for how it works. Make the length of the rectangle as long as possible.

Measure the length of the rectangle using the ruler instrument. Measure from the top (as seen on the computer screen) to the bottom to get the length. Be sure your measurement includes the border of the figure.

**Problem 2 - The Width Of A Rectangle**

Find the width of the largest rectangle that you can make on the lab bench.

**Answer 2**

**Instructions For Problem 2**

The width of the rectangle is controlled by the width gadget. The width gadget has the letter **W** printed in the center. Drag the width gadget back and forth to get a feeling for how it works. Make the width of the rectangle as wide as possible.

Measure the width of the rectangle using the ruler instrument. Measure from side to side (as seen on the computer screen) to get the width. Be sure to include the border of the rectangle in your measurement.

**Problem 3 - Finding The Area (Length x Width)**

Find the area of the largest rectangle that you can make on the lab bench.

**Answer 3**

**Instructions For Problem 3**

Make sure the length and width of the rectangle are as large as they can be. They should be the same size as the length and width you found in problems 1 and 2. You might want to check them with the ruler just to be sure.

To find the area of the rectangle multiply the length times the width. For example, if the length were 4.5 inches and the width were 3.6 inches, then the area is

4.5 x 3.6 = 16.2 square inches

To find out how close you were to the actual area click on the value bar in the first instrument window - the window with the picture of a rectangle in it. The area of the rectangle will appear in the value bar and the computer will speak the number.

## Worksheet 3-2: Area Of A Circle

Name: ______________________ Date: __________

Teacher: ______________________

Class: ______________________ Score: __________

### What You Should Already Know

You should know how to use the ruler instrument to make length measurements. If you are using the ruler for the first time, other than Experiment 0, we suggest you try Experiment 2 before you do this one.

### Problem 1: Finding The Radius Of A Circle

First: Click on the value bar in instrument window 1 - the instrument window that is furthest away from the elapsed-time clock. The value bar should turn completely white.

Then: Find the radius of the largest circle that you can make on the lab bench.

**Answer 1**

### Instructions For Problem 1

Before you start, check to see that the scale of the large ruler is showing inches with 1/10 inch divisions. The word **inches** should appear in the units bar of the ruler window, and the value bar will show the number zero as **0.00**. Click the units bar to change the units if you have to.

The radius of the circle is controlled by the radius gadget. The radius gadget has the letter **R** printed in the center. Drag the radius gadget back and forth to get a feeling for how it works. Make the radius as large as possible.

Measure the radius of the circle using the ruler instrument. Be sure to include the perimeter of the circle in your measurement.

**Problem 2: Finding The Area (3.14 x radius x radius)**

Find the area of the largest circle that you can make on the lab bench.

**Answer 2**

**Instructions For Problem 2**

Make sure that the radius of the circle is as large as it can be. It should be the same size as the radius you found in Problem 1. You may want to check it using the ruler.

To find the area of a circle you multiply

3.14 x radius x radius

For example, if the radius of your circle were 2.0 inches, than the area would be

3.14 x 2.0 x 2.0 = 12.56 square inches

To find out how close you were to the actual area, click on the value bar in the first instrument window - the one with the picture of the circle in it. The area of the circle will appear there.

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**Note:** If you use a calculator to compute the area and you want to be more accurate, than use the number 3.14159 instead of 3.14. This number is called Pi (pronounced pie) and on some calculators is shown as the symbol

## Worksheet 3-3: Area Of A Triangle

Name:______________________________ Date:__________

Teacher:____________________________________________

Class:_____________________________ Score:__________

### What You Should Already Know

You should know how to use the ruler to make length measurements. If you are using the ruler for the first time we strongly recommend that you do Experiment 2 first.

### Problem 1 - The Height Of A Triangle

First: Click on the value bar in instrument window 1 - the instrument window that is furthest away from the elapsed-time clock - until the number is covered by a white bar.

Then: Find the height of the largest triangle that you can make on the lab bench.

**Answer 1**

### Instructions For Problem 1

Before you start, check to see that the scale of the large ruler is showing inches with 1/10 inch divisions. The word **inches** should appear in the units bar of the ruler window, and the value bar will show the number zero as **0.00**. Click the units bar to change units if you have to.

The height of the triangle is controlled by the height gadget. The height gadget has the letter **H** printed in the center. Drag the height gadget up and down to get the feel of how it works. Make the height as large as possible.

Measure the height of the triangle using the ruler instrument. In this experiment you will be using the ruler in a slightly different way.

1) Drag the ruler to the triangle - don't release yet - and line up the top edge of the ruler with the top edge of the height gadget.
2) Now release the mouse button to start the measurement.
3) Move the ruler down until the top edge of the ruler rests along the bottom edge of the triangle. Move the ruler along the bottom edge of the triangle until the line drawn by the ruler is straight up and down (vertical).
4) Now click the mouse button to end the measurement. Write down the number for the height.

**Problem 2 - The Base Of The Triangle**

Find the base of the largest triangle that you can make on the lab bench.

**Answer 2**

**Instructions For Problem 2**

The size of the base of the triangle is controlled by the base gadget. The base gadget has the letter **B** printed in the center. Drag the base gadget back and forth to get an idea of how it works. Make the base of the triangle as large as possible.

Measure the base of the triangle using the ruler instrument. Again you will use the ruler in a slightly different way.

1) Drag the ruler to the triangle - don't release yet - and line up the **right** edge of the ruler with the right side (outside) of the triangle. Keep the ruler near the bottom of the triangle.

2) Now release the mouse button to start the measurement.

3) Move the ruler until the right edge of the ruler just touches the **left** edge of the base gadget. Slide the ruler along the edge of the base gadget until the line drawn by the ruler is straight (horizontal).

4) Now click the mouse button to end the measurement. Write down the size of the base.

**Problem 3 - Finding The Area ( 1/2 x Base x Height )**

Find the area of the largest triangle that you can make on the lab bench.

**Answer 3**

**Instructions For Problem 3**

Make sure the base and height of your triangle are as large as they can be. They should be the same base and height as you found in Problems 1 and 2. Check them to be sure.

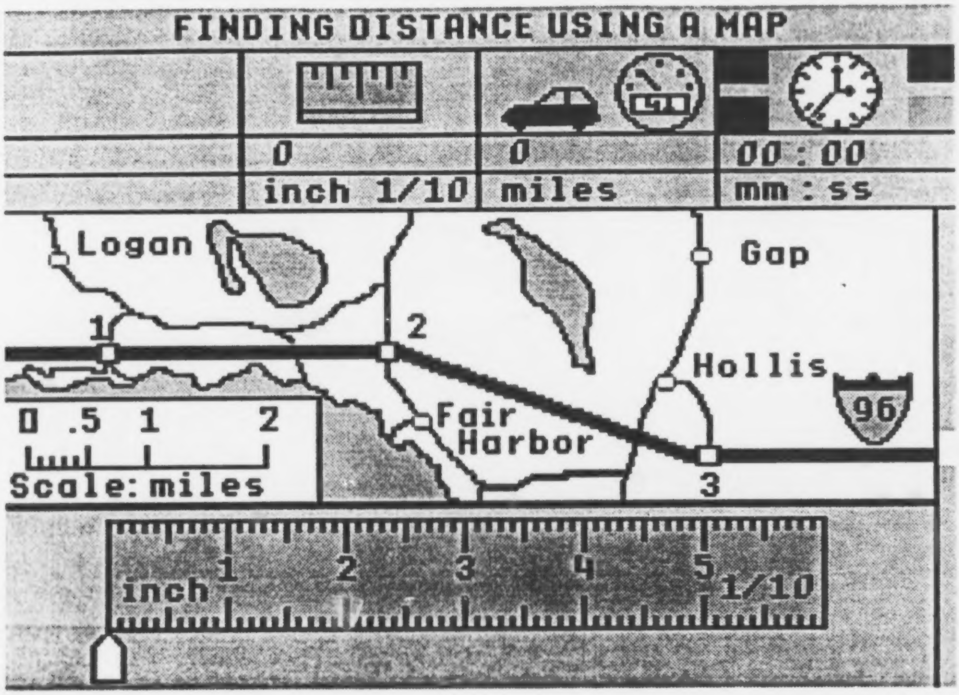
To find the area of a triangle you multiply 1/2 times the base times the height (you can use 0.5 instead of 1/2). For example, if your base is 2.0 inches and your height is 3.0 inches then the area of the triangle would be

1/2 x base x height = area

1/2 x 2.0 x 3.0 = 3.0 square inches.

Click on the value bar in instrument window 1 to see the actual area for your triangle. The triangle icon should be on the shelf.

## Introduction to Experiment 4:
## Finding Distance Using a Map


FINDING DISTANCE USING A MAP
0
inch 1/10
0
miles
00 : 00
mm : ss
Logan
Gap
1
2
Hollis
96
Fair Harbor
3
0 .5 1 2
Scale: miles
inch
1
2
3
4
5
1/10

**Experiment 4: Finding Distance Using A Map**
**Starting Screen, Ruler With 1/10 Inch Divisions**

**Objectives**

This environment is designed to help students learn how to read the scales associated with a ruler, as well as learn how to use a ruler to find distances on a map. An additional goal is to help students make the transition from real to abstract spatial measurements.

## Features

### General Description:

The ruler instrument is used to make length measurements of the objects located on the lab bench. As the student makes the measurements, the distance being measured is displayed in the value bar of the ruler instrument. At the same time a pointer points out the distance on a full-sized ruler shown on the screen. The student may choose to show or hide the numbers displayed in any of the value bars. If the value bar is not hidden when a measurement is completed, the measurement will be spoken by the computer.

Measurements are made on a map. By clicking on the units bar of the ruler the units of measurement can be changed to inches, centimeters, millimeters, miles or kilometers. The scale of the map can also be changed to miles or kilometers. Once distance measurements have been completed using a ruler, the car shown in instrument window 3 can be driven over the route to provide a check on the student's calculations. Distance driven in miles or kilometers is shown in the car value bar. Clicking on the trip odometer resets the distance traveled to zero.

### The Ruler Instrument:

The ruler instrument appears on the shelf in instrument window two at the start of the experiment. A length measurement is made with the ruler by using it to identify the beginning and ending point of a measurement.

Positioning the ruler to begin a Measurement

Drag the ruler to its starting location. (Move the mouse pointer over the ruler and press the mouse button. While pressing the mouse button, move the mouse - and consequently the ruler - to the desired starting location.)

Beginning the measurement

Release the mouse button. (After dragging the ruler to the starting location, let up on the mouse button.)

When making horizontal measurements you can align the left edge of the ruler with the starting location on the object being measured. When making vertical measurements you can use the top edge of the ruler. See what happens when you start from other locations on the ruler.

Marking off the distance

Move the mouse to the ending location. A line will be drawn on the screen as you move the mouse. The length of that line is the current distance you will have moved from the beginning position.

Ending the measurement

Click when you have reached the ending location. (Press and release the mouse button quickly.)

The mouse pointer will reappear. You are free to display the measurement in different units at this time. If the value bar is not hidden the computer will also "speak" the number shown in the value bar. The measurement is the length of the colored line that has been drawn on the screen.

### The Large Ruler:

The large ruler appears in the lower half of the computer screen. The scale on the large ruler corresponds to the units appearing in the units bar of the ruler instrument window. The units of measurement and, correspondingly, the scale on the large ruler can be changed by clicking on the units bar, itself.

Six different units of measurement are available.

**inches** by 1/8 inch divisions - distance is reported to the nearest 1/16 inch.

**inches** by 1/10 inch divisions - distance is reported to the nearest 0.05 inches.

**centimeters** by 1/2 centimeter divisions - distance is reported to the nearest 0.1 centimeters.

**millimeters** by 5 millimeter divisions - distance is reported to the nearest millimeter.

**miles** by 0.1 mile divisions - distance is reported to the nearest 0.05 miles.

**kilometers** by 0.2 kilometer divisions - distance is reported to the nearest 0.1 kilometer.

**The Car:**

A movable car is parked in instrument window 3. As the car is moved across the map, the distance traveled appears in the value bar of the car instrument window. By clicking on the speedometer/odometer icon in window 3, the mileage can be reset to zero. Clicking on the units bar in instument window 3 causes the units of distance to toggle between miles and kilometers.

The car is controlled by the mouse in much the same fashion as the ruler (see above). Drag the car to its starting location. Release the mouse button and move it so that the car travels over the route desired. Any movement of the car in this mode - backwards or forwards - causes the distance traveled to increase. Click the mouse button at the end of your trip. The mouse pointer will reappear and the car will no longer be under mouse control.

**The Map:**

The scale of the map is shown in the map legend. It is fixed at 1 inch = 1 mile. The legend can be changed to show the same scale in kilometers where 1 inch = 1.6 kilometers. Clicking on the units bar in instrument window 3 causes the scale display to toggle between miles and kilometers. Consequently, the units of distance traveled by the car will always agree with the units on the map scale.

## Worksheet 4-1: Measuring Map Distance

Name:________________________ Date:__________

Teacher:________________________________________

Class:________________________ Score:__________

### What You Should Already Know

You should know how to measure length using the ruler instrument. If you are using the ruler for the first time, you should begin with Experiment 2: Finding Length And Width.

### Problem 1 - Measuring Distances In Inches On A Map

Measure the distance in inches between exit 1 and exit 2 along interstate highway 96.

### Answer 1

### Instructions For Problem 1

Interstate highway 96 is the thick green line running across the map. Exit 1 is the small white rectangle with the number 1 printed next to it. Exit 2 has the number 2 printed next to it.

Click on the units bar in the ruler window until the large ruler on the lab bench shows the word **inch** and the fraction **1/10**. Using the ruler instrument, measure the distance from the center of exit 1 to the center of exit 2.

**Problem 2 - Changing Inches To Miles**

Using the map scale, find out how many miles you must travel for each inch of distance on the map.

**Answer 2**

**Instructions For Problem 2**

Find the map scale. It has the words **Scale:miles** printed below it. The scale is marked with numbers from 0 to 2. These numbers show the distance in miles on the map.

Using the mouse, drag the ruler to the **0** mark on the scale and release. Move the ruler exactly 1 inch along the scale then click. Write down the number of miles you traveled along the scale by reading the numbers on the scale. This is the number of miles you travel for each inch of distance on the map.

**Problem 3 - Calculating Distances In Miles**

How far is it in miles from exit 1 to exit 2 along interstate 96?

**Answer 3**

**Instructions For Problem 3**

You know the distance in inches from exit 1 to exit 2 (the answer to problem 1). You also know how many miles you travel for each inch of distance along the map (the answer to problem 2).

Multiply the distance in inches times the number of miles per inch to give you the correct answer.

**Problem 4 - Distance In Miles**

How many miles is it between exit 2 and exit 3 along the interstate highway?

**Answer 4**

**Instructions For Problem 4**

Follow the instructions given in problems 1 through 3.

## Worksheet 4-2: Measurement Issues

Name:______________________________ Date:__________

Teacher:____________________________________________

Class:_____________________________ Score:_________

### What You Should Already Know

You should know how to measure length using the ruler instrument. If you are using the ruler for the first time, you should begin with Experiment 2. If you are working with the map experiment for the first time you should begin with Worksheet 4-1: Measuring Map Distance.

### Problem 1 - Finding The Distance Between Two Towns

Find the distance along the road (red) in miles from the town of Gap to the town of Fair Harbor.

### Answer 1

### Instructions For Problem 1

Use the ruler instrument to measure the distance along the road. Since the ruler doesn't bend, you will need to measure a series of short, straight-line distances, and then add them up after you reach your destination.

The following technique will help make the measurements easy.

Drag the ruler to the town of Gap and release the mouse with the upper-left corner of the ruler in the center of town. Move the ruler down the road until the line drawn by the ruler begins to go off the road. Carefully click the mouse leaving the ruler in the same spot on the road. Record the distance traveled in inches.

**If the ruler is in the same spot**, just click the mouse to start the next measurement; move it until the ruler line goes off the road, and click it again. Record the distance moved in inches.

**If you accidentally move the ruler** away from the last spot on your way, simply drag it back to that spot and release the mouse to start the measurement; move it to the next point; and click to stop. Record the distance moved in inches.

Repeat the process of clicking to start, moving the ruler until the ruler line goes off the road, and clicking to stop, as you measure your way to Fair Harbor.

When you reach your destination, add up all the distances in inches. Then multiply this sum by the number of miles per inch that you found in problem 2 on Worksheet 4-1.

**Problem 2 - Differences In Measurements**

Find the distance from Gap to Fair Harbor again. Use the same method you used for problem 1. Is the result the same? If it is different can you explain why?

**Answer 2**

**Instructions For Problem 2**

Follow the same instructions given for problem 1.

**Worksheet 4-3: Ruler With 1/10 Inch Scale Divisions**

| | |
|---|---|
| Name: ______ | Date: ______ |
| Teacher: ______ | |
| Class: ______ | Score: ______ |

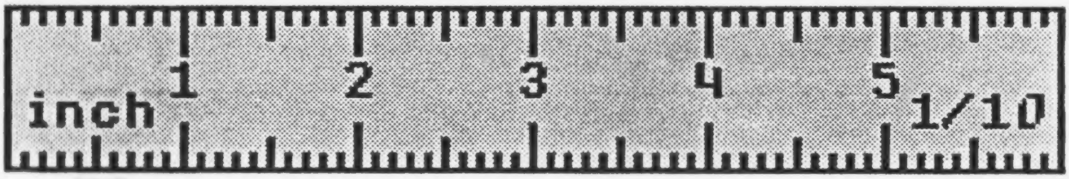
**What You Should Already Know**

It would be helpful to have already completed Worksheets 4-1 and 4-2 in this series.

**Problem 1 - Reading The Scale Marks On The Ruler**

Find and circle the scale marks on the ruler shown below that mean: "a distance of 3.10 inches from the left edge of the ruler."

**Answer 1**



**Instructions For Problem 1**

Make sure that the value bar in the ruler instrument window is not hidden. Click on the value bar if the number there is hidden.

Click on the units bar until the large ruler on the lab bench has the word **inch** on one side and the fraction **1/10** on the other. It should look like the picture in answer box 1.

Drag the ruler instrument to the lab bench, and release the mouse when the upper-left corner of the ruler rests on exit 1 of interstate highway 96.

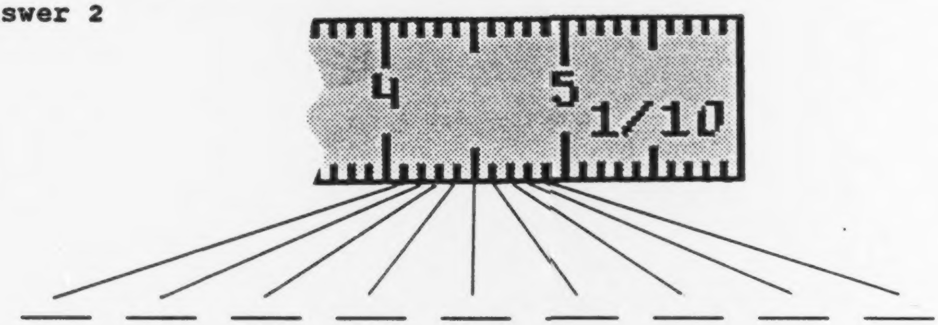
Move the ruler slowly toward the other side of the map. As you move the ruler the distance moved is shown in inches in the value bar. Also, a moving white pointer points to the same distance on the scale of the large ruler.

When the number in the value bar reaches 3.10, click the mouse. Look at the white pointer next to the large ruler. The scale mark nearest the white pointer also means 3.10 inches. Circle the mark nearest the white pointer and the mark directly above it.

**Problem 2 - Identifying All The Scale Marks Along 1 Inch**

In the space provided, write the numbers that match the scale marks between the 4.00 and 5.00 inch marks on the ruler.

**Answer 2**



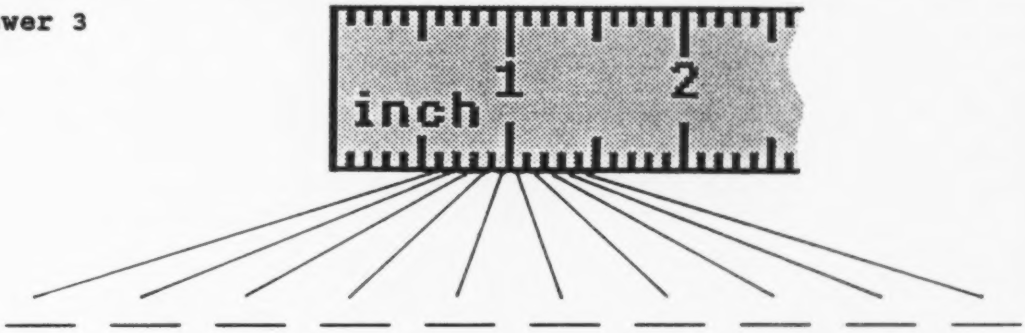
**Instructions For Problem 2**

Follow the instructions for problem 1, but this time watch the scale on the large ruler as you move the ruler instrument. When the white pointer is next to one of the marks that you must identify for this problem, read its value in the value bar.

**Problem 3 - Finding The Values Between The Scale Marks**

In the spaces provided below, write the numbers that match the location where each line is pointing on the ruler scale. The lines are all pointing between the scale marks.

**Answer 3**



**Instructions For Problem 3**

Follow the instructions for Problem 1, but move the ruler so that the white pointer rests between the scale marks. Read the matching number in the value bar.

**Problem 4 - Scale Divisions**

What is the length of the smallest scale division on the ruler shown in answer box 1. State your answer in inches.

**Answer 4**

**Instructions For Problem 4**

A **scale division** is the distance between two scale marks of the same length on the ruler scale. The length of the smallest scale division is the distance between two of the scale marks that are closest together. Usually they are also the shortest scale marks on the scale.

Using the ruler instrument, measure the distance between any two of the scale marks that are closest together on the large ruler. Be careful to measure from the same point on each mark.

**Discussion Questions**

1. What is the smallest distance that you can measure with the ruler shown in answer box 1?

2. What is the largest scale division shown on the ruler in answer box 1?

3. Which is smaller: a 1/2 inch scale division or a 1/8 inch scale division?

4. When a ruler has 1/10 inch scale divisions, into how many parts is each inch on the ruler divided?

## Worksheet 4-4: Measuring Distances On Paper Maps

Name:______________________________ Date:__________

Teacher:______________________________________________

Class:______________________________ Score:_________

**What You Should Already Know**

You should have done Worksheets 4-1 and 4-2. You should know how to read the scale on a ruler with ten divisions to the inch.

**Problem 1 - Finding The Distance In Inches**

Use the map on Page 4, and a 3 inch by 5 inch card, to find the distance in inches from the town of Gap to the town of Fair Harbor. Check your answer using the results you got from Worksheet 4-2.

**Answer 1**

**Instructions For Problem 1**

For this experiment you will need a pencil and a stiff piece of paper - a 3 inch by 5 inch card would be perfect. Ask your teacher if he or she will give you one. Use the map on Page 4 of this Worksheet.

Place the corner of the card in the center of the town of **Gap**. Hold the card so that the long edge is heading down the road in the direction of **Hollis**.

Put a mark on the card where the road bends and the edge of the card leaves the road.

Leave your pencil on the map at the same spot where you marked the card. Make sure the last mark on the card is next to the pencil point. Turn the card until the edge of the card near the mark is back on the road.

Put another mark on the card where the edge of the card leaves the road.

Continue to turn the card and mark it until you reach the town of Fair Harbor, where you put your last mark on the card. The distance from the corner of the card to the last mark is the total distance from Gap to Fair Harbor.

Use the large ruler shown on Page 3 to measure the total distance in inches marked on your card.

**Problem 2 - Changing Inches To Miles**

Using the map scale on Page 4, find out how many miles there are for a distance of 1 inch on the map.

**Answer 2**

**Instructions For Problem 2**

Using the large ruler on Page 4, mark off exactly one inch on a clean edge of your 3 by 5 card.

Find the map scale on Page 4. Place one end of your inch at the beginning of the map scale. Read the number of miles at the other end of the inch. Write down the number of miles per inch for this map.

**Problem 3 - Changing Inches To Miles**

Change the number of inches you measured along the road to miles.

**Answer 3**

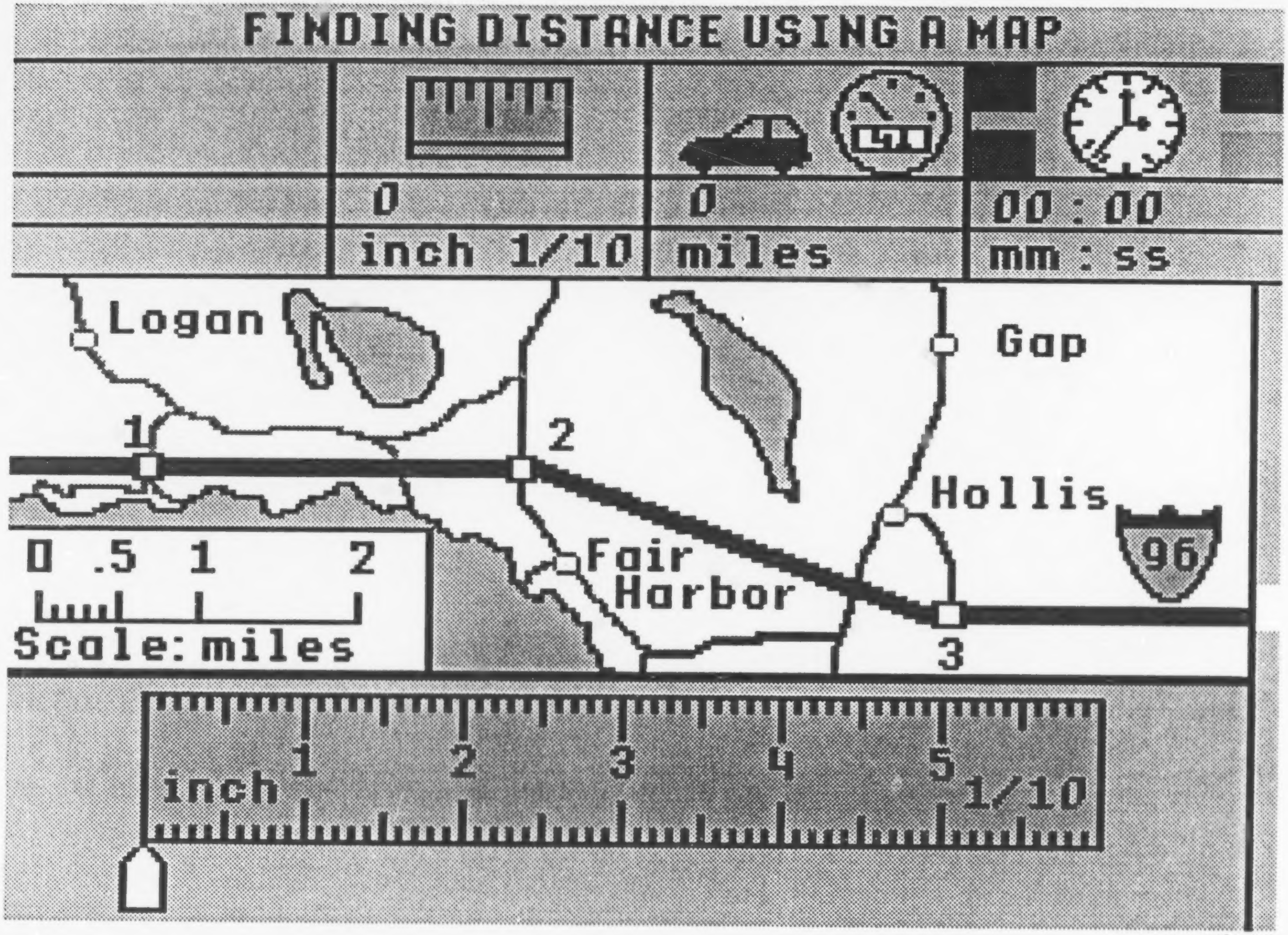
## Instructions For Problem 3

Multiply the distance in inches found in problem 1 by the number of miles per inch found in problem 2. Check your work using the results you got on Worksheet 2.

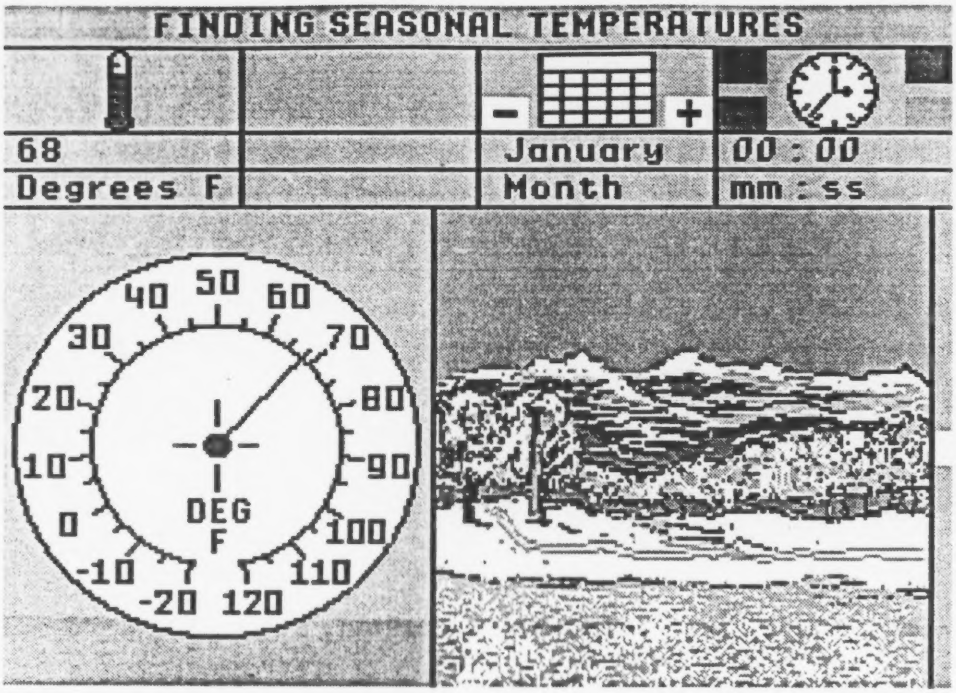
## Suggestions For Other Activities

Find a map of the state in which you live. Locate two towns on the map that you know and measure the distance in miles between. You will probably find that the map scale will be different from the one used here.

4 of 4


FINDING DISTANCE USING A MAP
0
inch 1/10
0
miles
00 : 00
mm : ss
Logan
Gap
1
2
Hollis
96
0 .5 1 2
Scale: miles
Fair
Harbor
3
inch
1
2
3
4
5
1/10

## Introduction to Experiment 5:
## Finding Seasonal Temperatures



FINDING SEASONAL TEMPERATURES

68

Degrees F

January

Month

00 : 00

mm : ss

**Experiment 5: Finding Seasonal Temperatures**
**Month Of January, Fahrenheit Thermometer Still On Shelf**

## Objectives

This environment is designed to help students learn how to read the scales associated with a circular thermometer. In addition, the student will be able to examine the variation in air and water temperature in a typical New England state throughout an entire year.

## Features

### General Description:

This environment features a thermometer instrument that can be used to measure temperature inside and outside the Physical Science Laboratory. Air and water temperatures can be measured outside the lab throughout an entire year. Both the month and the day of the month can be varied. The temperature read will be approximately equal to the average temperature for that day. The temperature inside the lab remains at a constant 68 degrees fahrenheit (20 degree celsius). The circular thermometer can show either a celsius or fahrenheit scale.

### The Thermometer Instrument:

The thermometer instrument resides on the shelf in instrument window 1. To use the thermometer, drag it to the desired location and release it. The thermometer will read the temperature directly under its bulb. Placing the bulb in the water will cause the water temperature to be read; placing the bulb anywhere else causes the air temperature to be read. As long as the thermometer is not on the shelf, it will register changes in temperature.

Each time the thermometer is released, the temperature at the current location will be voiced by the computer. Temperatures read by the thermometer instrument are registered in the value bar of the thermometer instrument window. The units are displayed in the units bar below. Clicking on the units bar will cause the value and units displayed to switch between fahrenheit and celsius degrees. Clicking on the value bar will either show or hide the current temperature value.

### The Large Circular Thermometer:

The large circular thermometer displays the temperature currently being sensed by the thermometer instrument. It is designed to give students practice in reading a circular scale by interpolation.

To switch the scale between celsius and fahrenheit on the large circular thermometer, click on the units bar in the thermometer instrument window.

### The Calendar:

The calendar appearing in instrument window 3 can be used to change the month of the year or the day of a particular month. Clicking on the units bar will cause either the word "Month" or

"Day" to appear in the units bar. Clicking on the **plus gadget** in the calendar window will cause either the month or day to advance by 1. The name of the month, or the day number, will appear in the value bar. Clicking on the **minus gadget** in the calendar window will cause the month or day to decrease by 1.

Attempting to advance the day number beyond the last day of the month, causes the day numbers to begin anew at day 1 for that same month. Attempting to decrease the day number below day 1, causes the day number to wrap to the last day for that month.

Note that it is possible to change the month or day while time is stopped (clock not running): neither the scene nor the temperature will change, however.

### Outside The Lab:

The scene outside the lab changes to reflect the month currently selected. Changing the day number has no effect on the visual scene. Both the temperature of the lake and the air can be measured on a daily basis. The temperatures are typical for the New England region of the United States. The temperature of the air is the average temperature for a given day.

To cause the scene or temperature to change, time must be advancing, i.e., the elapsed-time clock must be running. If the clock were stopped, it would be possible to show January in the value bar, while the scene displayed is the month of June. By stopping the clock, you can quickly advance through a number of months, without waiting for a scene change.

If the lake is frozen over, than the temperature of the surface of the lake will be the same as the air temperature.

### The Elapsed-Time Clock:

While the elapsed time clock is running, any changes made to the month or day via the calendar window will cause an appropriate change of scene or temperature. If the clock is not running, it is still possible to advance the month or day via the calendar window, but neither the scene nor the temperature will change.

## Worksheet 5-1: Measuring Air And Water Temperatures

Name:______________________________ Date:__________

Teacher:________________________________________

Class:______________________________ Score:__________

**Problem 1 - Measuring The Air Temperature**

Measure the outdoor air temperature in degrees Fahrenheit on the first day of January.

**Answer 1**

### Instructions For Problem 1

The lab bench is divided into two sections. On the left is a large thermometer that shows the same temperature as the thermometer instrument. On the right is the scene outside the Physical Science Laboratory. To measure outdoor temperature you will place the thermometer instrument outside.

**First: Set the month and day using the calendar window.**

1) Stop the elapsed-time clock by clicking on the STOP gadget.

2) Click on the units bar in the calendar window until the word **month** appears in the units bar. Click on the plus gadget (**+**) or minus gadget (**-**) until **January** appears in the value bar.

3) Click on the units bar in the same window until the word **day** appears. Click on the plus or minus gadget until the number **1** appears in the value bar.

**Second: Use the thermometer instrument to measure the outside temperature.**

1) Click on the units bar in the thermometer instrument window until the words **degrees F** (degrees Fahrenheit) are showing there.

2) If the value bar in the thermometer window is hidden, click on it once to make the number appear.

3) Drag the thermometer instrument from its shelf or any other location and release it in the outdoors. The temperature of the current scene will be announced by the computer.

4) Start the elapsed-time clock by clicking on the START gadget.

**If necessary**, the scene will change to January and the temperature in the value bar will show the average temperature for the first day of January.

**Problem 2 - Measuring Water Temperature**

Find the temperature of the lake in degrees Fahrenheit on July first.

**Answer 2**

**Instructions For Problem 2**

Set the month and day to **July 1** in the calendar window. Follow the instructions given in problem 1. Don't forget to STOP the clock before you begin; START it again when you are done.

Use the thermometer instrument to measure the temperature of the water. Drag the thermometer into the lake. Make sure that the thermometer bulb - the rounded, bottom portion - is in contact with the water. Release the mouse button to measure the temperature.

## Worksheet 5-2: Temperature Extremes

Name:____________________ Date:__________

Teacher:____________________

Class:____________________ Score:__________

### What You Should Already Know

We recommend that you do Worksheet 5-1: **Measuring Air And Water Temperatures**, before you try the problems on this worksheet.

Remember that the air temperature for a given day in this experiment is the average temperature for that day. The high and low temperatures could easily be twenty degrees higher or lower.

### Problem 1 - Coldest Part Of The Year

What are the dates of the coldest part of the year as measured by the air temperatures. Give the months and days when it is coldest.

### Answer 1

### Instructions For Problem 1

Use the thermometer instrument and explore the temperatures throughout the months and days of the year. Use the calendar window to change the months and days.

**Problem 2 - Warmest Part Of The Year**

What are the dates of the warmest part of the year as measured by the air temperatures? Give the months and days.

**Answer 2**

**Problem 3 - A Frozen Lake**

During what months is the lake frozen over? What temperature do you measure for the lake when it is frozen over? What are you actually measuring?

**Answer 3**

## Worksheet 5-3: Changing Temperatures

Name:______________________________ Date:__________

Teacher:________________________________________

Class:______________________________ Score:__________

### What You Should Already Know

We recommend that you do Worksheet 5-1: **Measuring Air And Water Temperatures**, before you try the problems on this worksheet.

Remember that the air temperature for a given day in this experiment is the average temperature for that day.

**Problem 1 - Fast Rising Temperatures**

During what month of the year do we have the biggest rise in temperature from the beginning of the month to the end of the month?

**Answer 1**

### Instructions For Problem 1

1) Use the thermometer instrument to measure the temperatures at the beginning and end of each month.
2) Find those months where the temperature at the end of the month is bigger than the temperature at the start of the month.
3) Subtract the temperature at the start of each of those months from the temperature at the end of each of those months. Look for the biggest difference.

You will find a table on the next page to help you organize the data.

## Temperature Data And Calculations To Find The Biggest Rise In Temperature

| Month | Temperature Begin | Temperature End | Positive Difference (End - Begin) |
|---|---|---|---|
| | ______ (units) | ______ (units) | ______ (units) |
| JAN | | | |
| FEB | | | |
| MAR | | | |
| APR | | | |
| MAY | | | |
| JUN | | | |
| JUL | | | |
| AUG | | | |
| SEP | | | |
| OCT | | | |
| NOV | | | |
| DEC | | | |

## Worksheet 5-4: Temperature Scales

Name:______________________ Date:__________

Teacher:______________________________

Class:______________________ Score:__________

**Problem 1 - Find The Missing Numbers**

Complete the following table by filling in the temperatures in degrees Celsius that match the temperatures in degrees Fahrenheit.

**Temperature Table**
**Changing From Fahrenheit To Celsius Degrees**

| Degrees Fahrenheit | Degrees Celsius |
|---|---|
| 5 | _____ |
| 14 | _____ |
| 23 | _____ |
| 32 | ___0_ |
| 41 | _____ |
| 50 | _____ |
| 59 | _____ |
| 68 | _____ |
| 77 | _____ |
| 86 | _____ |

**Instructions For Problem 1**

1) Click on the units bar in the thermometer window until the units are **degrees F.**
2) Find a day during the year when the temperature in degrees Fahrenheit is equal to one of the numbers in the table.
3) Click on the units bar to convert the temperature in degrees Fahrenheit to the temperature in degrees Celsius. Read the Celsius value in the value bar. Write it in the table.

Repeat steps 1 through 3 (don't forget 1, it's easy to forget) until you have found all the numbers you can.

**Problem 2 - Using Patterns In Numbers**

Use the way the numbers are changing in the table to help you fill in the missing numbers.

**Problem 3 - Making Up Rules**

Finish the following rule about the way the numbers are related:

Whenever the Fahrenheit temperature changes by _____ degrees, the Celsius temperature changes by _____ degrees.

## Worksheet 5-5: Reading A Circular Thermometer

Name:__________________________________ Date:___________

Teacher:________________________________________________

Class:__________________________________ Score:___________

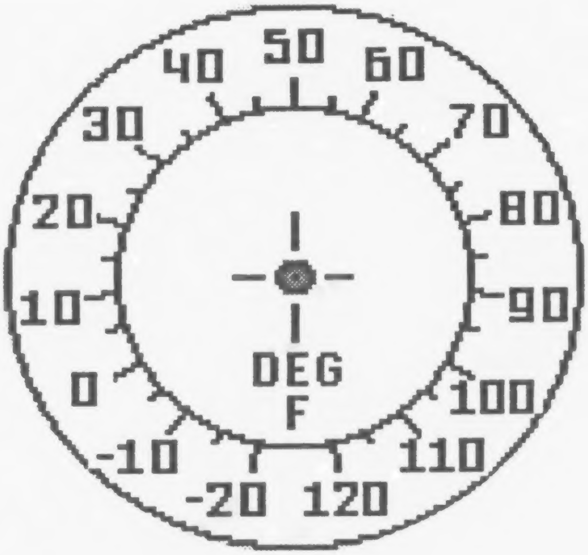
### What You Should Already Know

We recommend that you do Worksheet 5-1: **Measuring Air And Water Temperatures**, before you try the problems on this worksheet.

### Problem 1 - Reading The Scale Marks On The Thermometer

On the circular thermometer shown below, draw a pointer from the center to the scale mark that means "45 degrees Fahrenheit".

**Answer 1**



**Instructions For Problem 1**

1) Make sure that the value bar in the thermometer window is not hidden. Click on the value bar if it is hidden until the number appears.

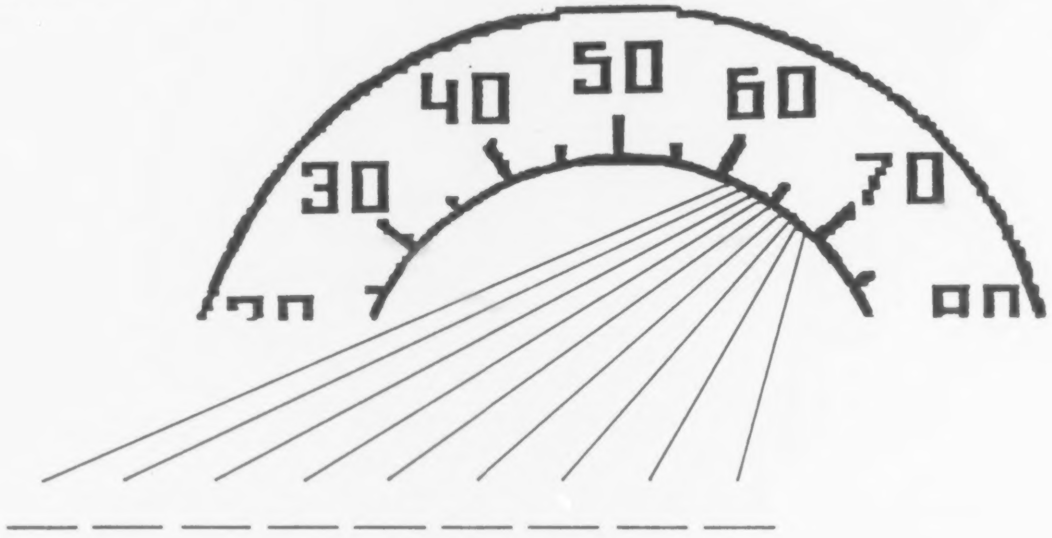
2) Click on the units bar until the words **degrees F** (degrees Fahrenheit) appear there.

3) Using the calendar window, select a day during the year that has an average temperature of 45 degrees Fahrenheit. When the value bar displays **45**, note the position of the red pointer on the large thermometer; the end of the pointer will be next to the 45 degree Fahrenheit scale mark.

**Problem 2 - Reading Between The Lines: Interpolation**

Fill in the values that match the points on the temperature scale shown below.

**Answer 2**



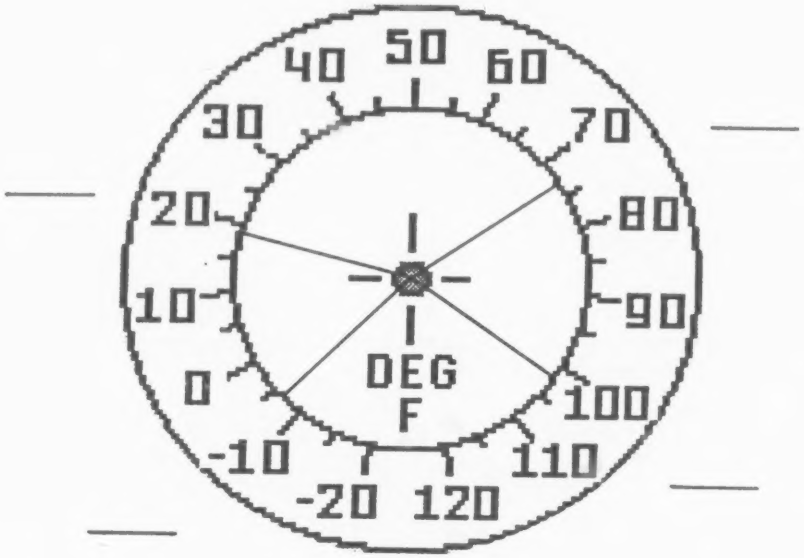
**Instructions For Problem 2**

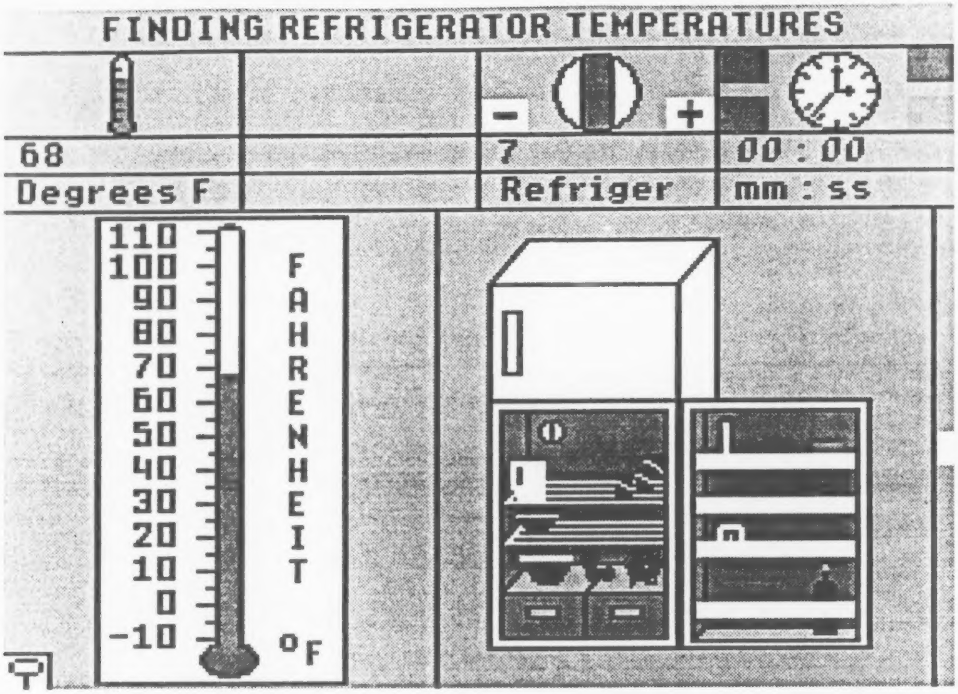
Follow the instructions for problem 1 except that you will need to find temperatures that match the points shown in answer box 2.

**Problem 3 - Testing Yourself**

Write down the temperature values pointed to by the pointers. Use the nearest space provided outside the thermometer.

**Answer 3**


40
50
60
30
70
20
80
10
90
0
DEG
F
100
-10
110
-20
120



FINDING REFRIGERATOR TEMPERATURES

68
Degrees F

7
Refriger

00 : 00
mm : ss

**Experiment 6: Refrigerator**
**Refrigerator Door Open To Room Temperature**

## Objectives

This environment is designed to help students learn how to read the scales associated with a thermometer, as well as learn how to use the thermometer instrument in the Physical Science Laboratory. In addition, the student can learn about temperature conditions in the family refrigerator and can learn to control those conditions.

## Features

### General Description

This simulation allows students to measure temperatures in the refrigerator and freezer compartments of a typical family refrigerator. The student can also control the rate of cooling in the refrigerator by adjusting the refrigerator thermostat. The thermostat has 10 different settings including an OFF position.

The doors of the refrigerator open and close. The thermometer instrument can be placed inside the refrigerator and the door(s) closed. When the refrigerator or freezer door is closed, the temperature given is the average temperature of the contents of that compartment of the refrigerator. When the door is opened, the temperature given is the temperature of the air in the room.

The left-hand side of the lab bench exhibits a large thermometer whose scale is readable as the liquid in the tube rises and falls with a change in temperature. Two scales are available: fahrenheit and celsius. The fahrenheit scale includes a magnifying gadget that increases the size of the scale to give a more precise reading.

### The Refrigerator

#### The Doors:

Click on the door handles to open the refrigerator doors. "Push" an open door closed by clicking on it.

#### The Thermostat:

The temperatures in the refrigerator and freezer compartments are controlled by a single thermostat (the lead designer for this project owns an old refrigerator!). Once the thermostat is set, the refrigerator and freezer temperatures will each rise or fall to a particular value (but not the same value). Freezer temperatures range from -4 to 12 degrees F, while the refrigerator compartment ranges from just above 32 to 40 degrees F. Refrigeration can be turned off by setting the thermostat to the OFF position.

The thermostat control can be found in instrument window number 3. Clicking on the plus gadget will increase the setting while clicking on the minus gadget will decrease the setting. The current setting is shown in the value bar of the thermostat window.

The abbreviation "Refriger" appears in the units bar. The numerical value of the thermostat is not the actual temperature setting (as is the case for most refrigerators).

Selecting the thermostat control instrument, or the thermostat inside the refrigerator, will cause a large thermostat to appear in place of the large thermometer on the left-hand side of the lab bench. The scale can be easily read to show the current setting. It will, of course, agree with the numerical value shown in the value bar of the thermostat window. Selecting the thermometer instrument will cause the large thermometer to replace the large thermostat on the lab bench.

**Inside The Refrigerator:**

Because outside air rapidly infiltrates a refrigerator compartment (like those simulated here) when a door is opened, the temperature measured will always be the room temperature when a door is open. When a door is closed, the small amount of air inside cools rapidly to the temperature of the contents, thus the temperature of the contents determines the temperature measured when the door is closed with the thermometer inside.

If a door is left open, the temperature of the contents will gradually rise (and the refrigerator will run constantly). Close the door to measure the resulting rise in temperature.

**The Large Thermometer:**

The large thermometer appears on the lab bench whenever the thermometer instrument is selected. The liquid level changes to reflect changes in temperature being measured by the thermometer instrument. Both fahrenheit and celsius scales are available. Clicking on the units bar in the thermometer instrument window will change the scale depicted.

To toggle the magnification of the fahrenheit scale of the large thermometer, click on the magnifying gadget shown in the lower left-hand corner of the lab bench. Individual degrees can be read quite easily on high magnification.

**The Thermometer Instrument:**

The thermometer instrument resides on the shelf in instrument window 1. To use the thermometer, drag it to the desired location and release it. The thermometer will read the temperature directly under its bulb.

Each time the thermometer is released, the temperature at the current location will be voiced by the computer. Temperatures read by the thermometer instrument are registered in the value bar of the thermometer instrument window. The units are displayed in the units bar below. Clicking on the units bar will cause the value and units displayed to switch between fahrenheit and celsius degrees. Clicking on the value bar will either show or hide the current temperature value.

To read the average temperature of the contents of the refrigerator or freezer, place the thermometer instrument inside the refrigerator and **close the door** of the refrigerator or freezer.

You will probably want to speed time up quite a bit to observe changes in the temperature readings while manipulating the environment.

## Worksheet 6-1: Inside Your Refrigerator

Name: ______________________________ Date: __________

Teacher: ____________________________________________

Class: _____________________________ Score: __________

**Problem 1: Look Inside The Refrigerator And Freezer**

You are very hot and thirsty and need something cold to drink. See if you can find what it is you need in the refrigerator. You might want to put ice in your drink. Open up the freezer and see what is in there. What did you find in the refrigerator to drink? What did you find in the freezer?

**Answer 1**

### Instructions For Problem 1

To open up a refrigerator you normally pull on the door handle. In this experiment you can open the refrigerator door by clicking on the door handle with the mouse. Try it.

To open up the freezer door click on the freezer door handle. Try it.

Take a look inside both the refrigerator and the freezer to answer the questions in Problem 1.

**Problem 2: Opening And Closing**

Now that you have the doors open see if you can close them. What else can you find in the refrigerator that opens and closes?

**Answer 2**

### Instructions For Problem 2

Hardly anyone uses the handle to close the door on a refrigerator. Besides, you can't reach it very easily because it's always on the other side when the door is open. Most of us just grab the door and push it closed. You can do the same thing with the mouse by just clicking anywhere on the open door. Try it.

**Problem 3: The Refrigerator Door Won't Close**

While opening and closing things belonging to the refrigerator, you can get into a situation where the door on the refrigerator will not close. Why won't the door of the refrigerator close and what do you have to do to fix the problem?

**Answer 3**

## Worksheet 6-2: Temperatures Inside A Refrigerator

Name:______________________ Date:__________

Teacher:______________________________

Class:______________________ Score:__________

**Problem 1 - Temperature Inside Refrigerator Compartment**

What is the temperature in degrees Fahrenheit inside the refrigerator?

**Answer 1**

### Instructions For Problem 1

1) Make sure that the value bar in the thermometer instrument window is not hidden, and change the units to **degrees F** in the units bar, if necessary.

2) Open the refrigerator door (not the freezer door). Drag the thermometer from the shelf and place it in the refrigerator. Notice that the temperature is 68 degrees F. This is because room air has entered the refrigerator.

3) Close the refrigerator door. Read the temperature in the value bar. Unless the refrigerator has been **OFF** for a long time the temperature should be less than 68 degrees F.

**Problem 2 - Temperature Inside Freezer Compartment**

What is the temperature in degrees Fahrenheit inside the freezer?

**Answer 2**

**Instructions For Problem 2**

Follow the instructions for problem 1 only this time place the thermometer inside the freezer rather than the refrigerator.

**Problem 3 - The Temperature Controller**

Find the temperature control instrument inside the refrigerator. Click on it. What is the current setting on the dial?

**Answer 3**

**Instructions For Problem 3**

The temperature control instrument, also called a thermostat, is on the back wall of the refrigerator compartment. Click on it to see the dial settings. The blue dot is positioned next to the current setting. Read the setting from the dial.

## Worksheet 6-3: Controlling Refrigerator Temperature

Name:______________________________________ Date:_____________
Teacher:_______________________________________________________
Class:______________________________________ Score:____________

### What You Should Already Know

We recommend that you do Worksheet 6-2: **Temperatures Inside A Refrigerator** before you begin this Worksheet.

### Problem 1 - Changing The Thermostat Setting

Change the thermostat setting of the refrigerator to **5**.

### Instructions For Problem 1

Use the thermostat control instrument in window 3. The units bar has the abbreviation **Refrig.** displayed in it. The thermostat setting controls the temperature inside the refrigerator. To change the setting click on the plus (**+**) or minus (**-**) gadget in the thermostat window. The current setting will appear in the value bar. Click on the plus or minus gadgets until the number **5** appears in the value bar.

If you click on the thermostat icon on the instrument shelf, a large thermostat dial will appear on the left-hand side of the lab bench. The setting on the dial should be the same as the one in the value bar.

### Problem 2 - What Will Be The Refrigerator Temperature

What temperature does the refrigerator reach when the thermostat is set to 5?

**Answer 2**

**Instructions For Problem 2**

1) Place the thermometer inside the refrigerator and close the door.

2) Make sure that the elapsed-time clock is turned off by clicking on the STOP button.

3) Adjust the clock speed-control to a factor of about 10. You only have to move it up very slightly.

4) Turn on the elapsed-time clock. Watch the value bar for the clock. A minute should click by in 6 seconds.

5) Watch the temperature in the value bar. It may change for a while, and then change hardly at all. You can speed up the clock even more if you like (Don't forget to stop the clock to do so). When the temperature seems to have reached a fixed value, record that number.

**Problem 3 - What Will Be The Freezer Temperature**

What temperature does the freezer reach when the thermostat is set to 5?

**Answer 3**

## Worksheet 6-4: Knowing Your Refrigerator Thermostat

Name: ________________________ Date: ____________

Teacher: ________________________________

Class: ________________________ Score: ____________

**Problem 1 - Collecting Thermostat Data**

Find the temperature that your refrigerator reaches for each setting of the thermostat. Write your data in the table below.

**Answer 1**
**Refrigerator Temperature Reached For A Given Thermostat Setting**

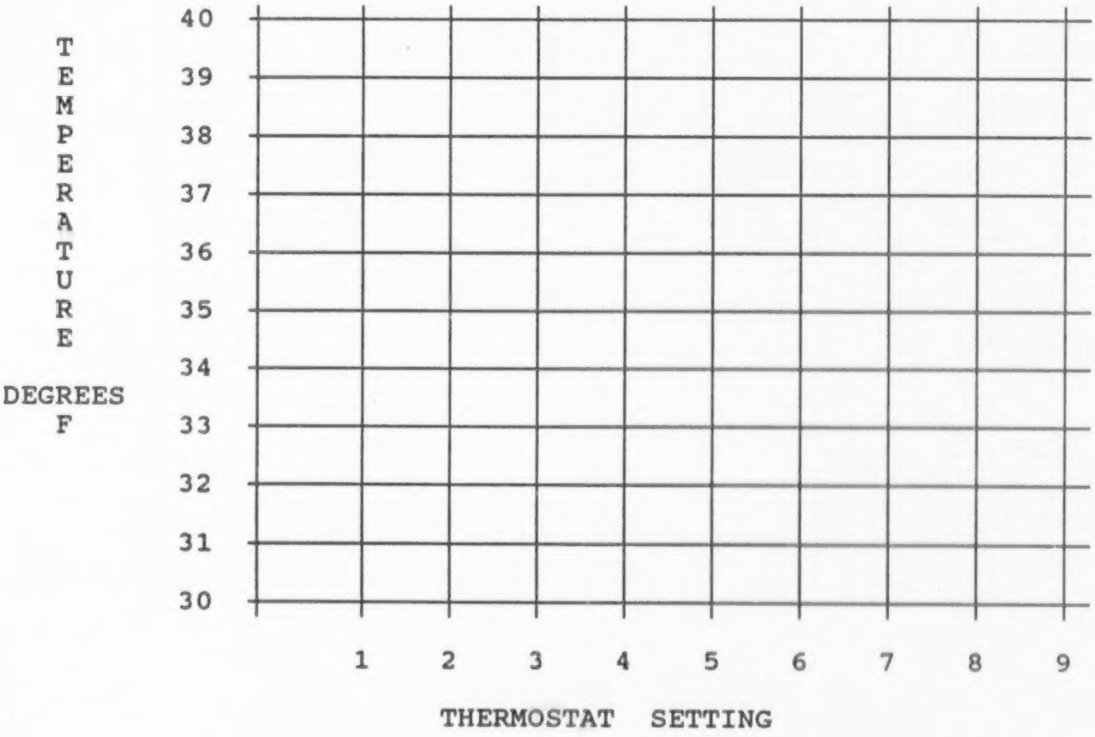
| Thermostat Setting | Refrigerator Temperature (degrees Fahrenheit) |
|---|---|
| OFF | _____ |
| 1 | _____ |
| 2 | _____ |
| 3 | _____ |
| 4 | _____ |
| 5 | _____ |
| 6 | _____ |
| 7 | _____ |
| 8 | _____ |
| 9 | _____ |

**Instructions For Problem 1**

Follow the instructions given in Activity Worksheet 6-3: **Controlling Refrigerator Temperature** to set the thermostat to one of the values shown below. Wait until the temperature is no longer changing. Then enter the value in the table. You will have to speed time up to do this experiment.

## Problem 2 - Make A Graph Of Your Data

Plot your data on the graph below.



## Worksheet 6-5: What If The Power Goes Off

Name:____________________________________ Date:____________

Teacher:____________________________________________________

Class:____________________________________ Score:____________

### Problem 1 - Collecting Temperature Data

Simulate a power failure to your refrigerator by turning the thermostat OFF. Measure the temperature in the refrigerator every two hours for 24 hours. Write your data below.

### Answer 1
### Refrigerator Temperatures With Thermostat OFF

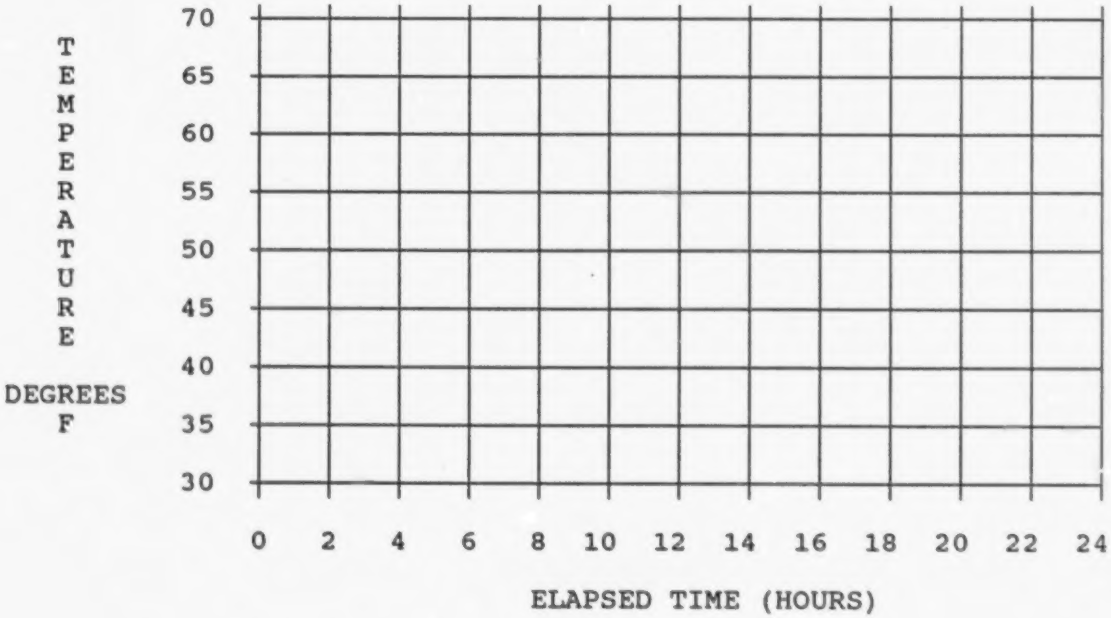
| Elapsed Time (Hours) | Refrigerator Temperature (Degrees F) |
|---|---|
| 0 | ______ |
| 2 | ______ |
| 4 | ______ |
| 6 | ______ |
| 8 | ______ |
| 10 | ______ |
| 12 | ______ |
| 14 | ______ |
| 16 | ______ |
| 18 | ______ |
| 20 | ______ |
| 22 | ______ |
| 24 | ______ |

**Instructions For Problem 1**

Cool your refrigerator down to 32 degrees F. Use the information you collected in Activity Worksheet 6-4: **Knowing Your Refrigerator Thermostat** in order to do this. Turn the thermostat to the OFF position. Stop the clock every two hours to record the temperature. You may want to speed time up to do this activity.

**Problem 2 - Make A Graph Of Your Time And Temperature Data**

Plot your data on the graph below.



## Worksheet 6-6: Reading A Thermometer

|  |  |
|---|---|
| Name:____________________ | Date:__________ |
| Teacher:____________________________ | |
| Class:____________________ | Score:__________ |

### Problem 1 - Reading The Scale Marks On A Thermometer

Draw an arrow to the scale mark on the thermometer that means: "a temperature of 32 degrees Fahrenheit."

### Instructions For Problem 1

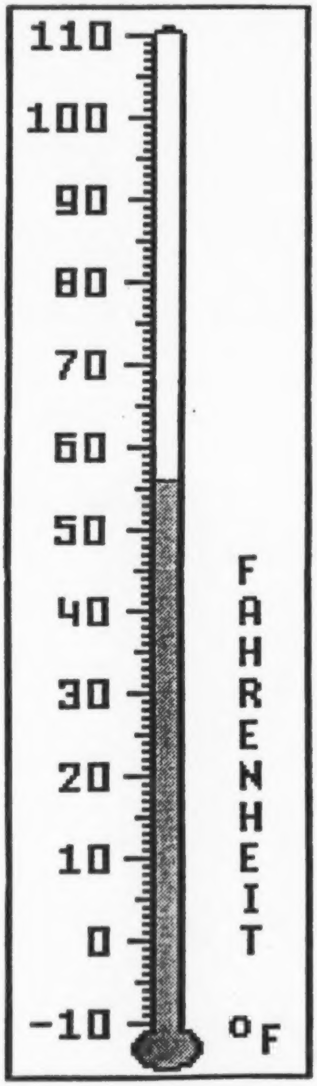
See the next page.

### Problem 2 - Reading The Temperature At The Liquid Level Of A Thermometer

Read the temperature indicated by the liquid level in the thermometer. Write the number next to the top of the liquid.

### Instructions For Problem 2

See the next page.



**Instructions For Problem 1**

1) Place the thermometer instrument in the refrigerator and close the door.

2) Bring the temperature in the refrigerator down to 32 degrees Fahrenheit. Use the thermostat setting you found in Worksheet 6-4: to do this.

2) When the value bar reaches 32, click on the magnifying gadget (it looks like a big magnifying glass) on the lower left side of the lab bench. A portion of a large thermometer will appear on the lab bench. It will be similar to the one on the Worksheet.

3) Look carefully at the liquid level of the thermometer on the lab bench. The scale mark nearest the liquid level is the 32 degree Fahrenheit mark. Draw an arrow pointing to the same scale mark on the Worksheet thermometer.

**Instructions For Problem 2**

1) Leave the thermometer instrument in the refrigerator. STOP the elapsed-time clock and use the speed-control to speed time up. START the clock again.

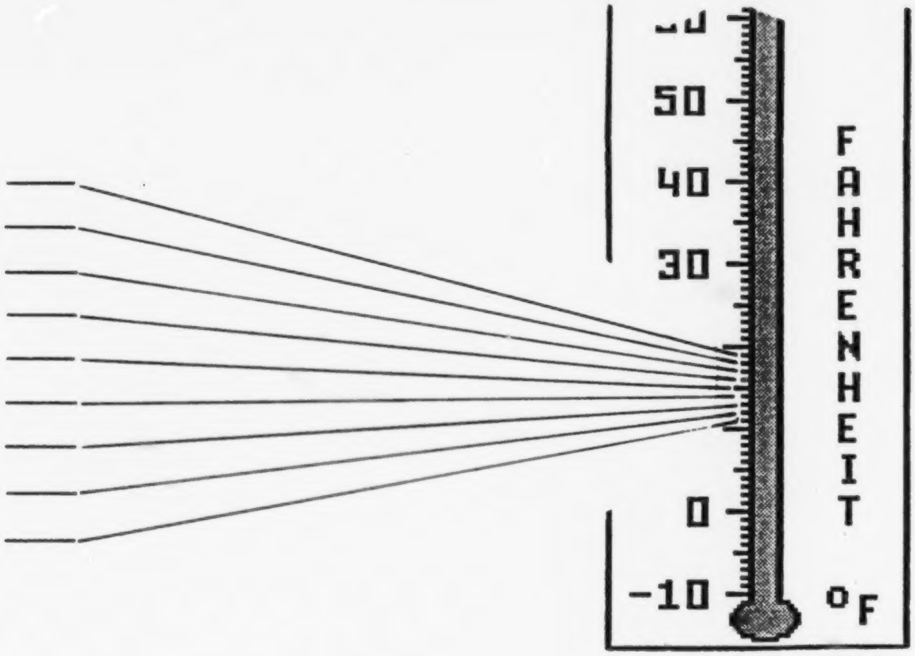
2) Turn the thermostat to the OFF position. Watch the liquid level until it climbs to the one in the drawing. You can stop the clock every now and then to make a closer check.

3) When the liquid levels are the same read the temperature in the value bar. If you go past the scale mark you can always cool the refrigerator to make the temperature go back down.

**Problem 3 - Naming All The Scale Marks Along 10 Degrees**

See the thermometer drawing on the next page. In the space provided, write the temperature that matches each of the scale marks.

**Answer 3**



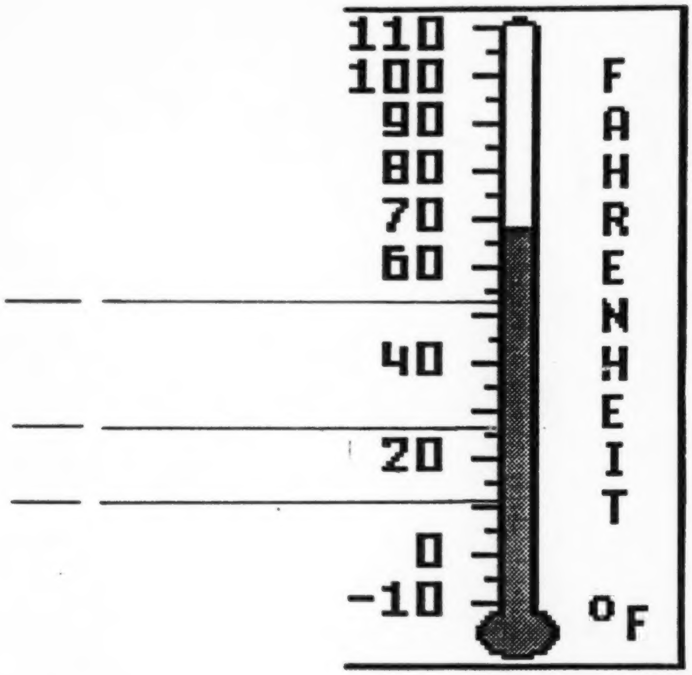
**Instructions For Problem 3**

Place the thermometer instrument in the freezer to see temperatures in this range. If they are too low you can turn the thermostat to OFF. If they are too high you can cool the freezer down.

**Problem 4 - Interpolation Of Temperature Readings**

Enter the temperatures to which the lines are pointing.

**Answer 4**



**Instructions For Problem 4**

Some thermometers do not have scale marks for each degree of temperature. By looking carefully at the scale you can often guess, within one or two degrees, what the actual temperature is.

In this problem you can help yourself by switching back and forth between the two Fahrenheit thermometers on the lab bench by using the magnifying gadget. Just click on it to switch from one to the other.

## Worksheet 6-7: In Your Own Refrigerator

Name:______________________________ Date:__________

Teacher:_____________________________________________

Class:______________________________ Score:__________

### What You Should Already Know

We recommend that you complete Worksheet 6-6: **Reading A Thermometer** before you do this Activity Worksheet.

### Problem 1 - The Temperature of Your Own Refrigerator

Using a special thermometer that your teacher will lend you until the next school day, measure the temperature of your refrigerator at home. Please ask permission from your folks at home before you try this.

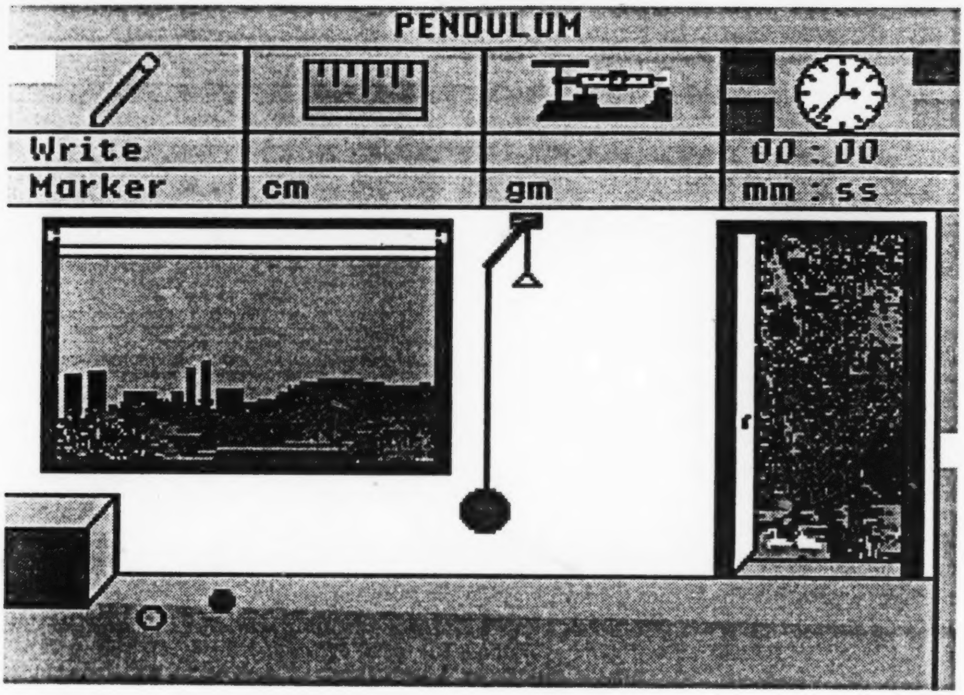
### Answer 1

### Instructions For Problem 1

Your teacher will lend you a thermometer that you can safely place in your home refrigerator. It is made of plastic and it is very strong. Nordic skiers often wear this kind of thermometer on their jackets so they can tell what kind of wax to put on their skis.

Place the thermometer where it can be reached easily. It will take a while for the thermometer to reach the refrigerator temperature. Leave it in until the temperature stops changing. If you leave it in for 10 minutes that should be enough.

When you take it out to read it, be quick about it because the temperature will begin to rise almost as soon as you take it out of the refrigerator.


PENDULUM
Write
Marker
cm
gm
00 : 00
mm : ss

**Experiment 7: Pendulum**
**Pendulum In Earth-Lab Environment**

### Objectives

This environment is designed to help students learn how a pendulum behaves under different experimental conditions, and in particular to learn how a pendulum can be used to measure the gravitational acceleration of the earth and the moon.

## Features

### General Description

This simulation allows students to perform experiments with a pendulum. The student can change to one of three different pendulum bobs during an experiment. The length of the pendulum can be varied by "pulling" on the cord attached to the pendulum bob. The pendulum experiments can be moved quickly between the earth and the moon. Measurement instruments are available to measure mass and length as well as elapsed time. A marker is available to mark the position of the pendulum.

The motion of the pendulum can be stopped at any time. While time is stopped, the pendulum may be positioned at any angular displacement between 0 and plus or minus 90 degrees. The pendulum will behave in a periodic manner for small angular displacements and will exhibit non-linear behavior for larger angular displacements. The motion of the pendulum is affected by air resistance while on earth, but air resistance is not a factor on the surface of the moon. A small amount of internal friction causes damping of the pendulum motion both on the earth and the moon.

One of the pendulum bobs (the hollow looking one) can be used to illustrate pendulum motion with only the force of gravity affecting the motion regardless of where the experiment is taking place: be it the earth or the moon. The chief use of the hollow bob is to illustrate those statements that begin, "Let us assume the absence of any friction...".

### The Pendulum

The pendulum is made up of two parts: the pendulum bob and the cord from which the pendulum bob is suspended.

**The Bobs:**

Three pendulum bobs are available during the simulation. The bobs may be interchanged by dragging one of the free bobs and releasing it on top of the suspended bob. When a bob is released or exchanged it automatically returns to one of the resting places on the lab floor. The mass of a pendulum bob can be measured by using the beam balance measurement instrument.

The hollow bob is special; when it is used as the pendulum bob no other forces other than the force of gravity are acting on the pendulum, i.e., internal friction and air resistance are absent. The other two bobs are assumed to be spherical in shape with the horizontal diameter being the closest to the intended diameter of the sphere.

**The Cord:**

The pendulum cord is held in position by a support extending from the lab wall. The length of the pendulum cord may be changed by pulling or pushing (actually dragging) the "ring" attached to the other end of the cord that passes through the support. The ring is the triangular shaped object at the other end of the cord. The length of the cord can be varied between 0.3 and 2.3 meters approximately. We have made the mass of the cord negligible relative to the mass of the pendulum bobs.

**Positioning The Pendulum:**

In order to manipulate the pendulum time must be stopped. Clicking on the **STOP button** will halt the pendulum's motion if it is moving. To position the pendulum simply drag the pendulum bob to the desired location. The available starting positions are of course constrained by the length of the cord. As long as time is stopped the pendulum will remain suspended in space where it was last placed. The angular displacement may vary between plus or minus ninety degrees.

## The Lab

**Window Shade And Door:**

The lab itself is designed to aid the experimenter in several ways. Of course there is the nice view, but if this interferes with taking data on the position of the pendulum, both the window shade and the door may be closed. To close (or open) the shade click on the lower end of the shade. To close or open the door, click on the door handle. The large white surface area available when the shade and door are closed may be used for marking the position of the pendulum with the marker instrument.

**Location:**

The lab may be transported to the surface of the moon for doing experiments. Simply click on the quarter moon that is barely visible in the earthan sky. If you want to return to earth when on the moon then click on the earth, which is visible from the window of the lunar lab.

Air affects the motion of the pendulum while on the earth, but there is no air in the lunar lab. Internal friction of the pendulum is present on both the earth and the moon (except when the hollow bob is used).

### The Beam Balance:

The beam balance may be used to measure the mass of the pendulum bobs. Drag the beam balance from the instrument shelf and position the platform of the beam balance directly under the bob being measured. The mass of the bob will be read when the button on the mouse is released. **The top of the platform and the bottom of the bob must be closely aligned in order to obtain a reading other than zero.** Return the balance to the instrument shelf when you are done using it.

### The Marker:

The marker can be used to mark the position of the pendulum when time is stopped. A **next gadget** appears in the marker window. Clicking on the next gadget flips the marker so that it becomes an eraser. The current mode is indicated in the value bar of the marker window.

To acquire the marker, make sure that time is stopped and click on the marker. Your pointer will disappear and the marker will now be attached to the mouse. Move the marker to where you want to write - don't drag it, just move it - and press the mouse button. A mark will appear just below the tip. Release the mouse button when you have finished marking.

To replace the mouse button on the shelf, move the marker to the shelf and click the mouse. Your pointer will reappear and the marker will be back on the shelf.

### The Ruler Instrument

The ruler instrument appears on the shelf in instrument window two at the start of the experiment. A length measurement is made with the ruler by using it to identify the beginning and ending point of a measurement.

### Positioning the ruler to begin a Measurement:

Drag the ruler to its starting location. (Move the mouse pointer over the ruler and press the mouse button. While pressing the mouse button, move the mouse - and consequently the ruler - to the desired starting location.)

**Beginning the measurement:**

Release the mouse button. (After dragging the ruler to the starting location, let up on the mouse button.)

When making horizontal measurements you can align the left edge of the ruler with the starting location on the object being measured. When making vertical measurements you can use the top edge of the ruler.

**Marking off the distance:**

Move the mouse to the ending location. A line will be drawn on the screen as you move the mouse. The length of that line is the current distance you will have moved from the beginning position.

**Ending the measurement:**

Click when you have reached the ending location. (Press and release the mouse button quickly.)

The mouse pointer will reappear. You are free to display the measurement in different units at this time. If the value bar is not hidden the computer will also "speak" the number shown in the value bar. The measurement is the same as the length of the colored line that was drawn on the screen when you positioned the ruler.

## Worksheet 7-1: Working With The Pendulum

Name:________________________________ Date:__________

Teacher:________________________________________________

Class:_______________________________ Score:__________

**Problem 1: "Close The Door, Close The Shade..."**

It's hard to get any work done with the shade and the door open. Close the door and the shade at least for now; you don't have to keep them closed. Where must you click with the mouse to close the door; to close the shade? How can you open them again?

**Answer 1**

**Problem 2: Bobbing Around**

Pick up one of the pendulum bobs on the lab floor and exchange it with the one that is hanging from the end of the cord. What happens during the exchange?

**Answer 2**

**Instructions For Problem 2**

Using the mouse, drag the pendulum bob that is on the floor over the pendulum bob that is on the end of the cord. Release. See what happens.

### Problem 3: Changing The Length Of The Pendulum

Make the length of the cord between the support arm and the pendulum bob longer or shorter. Is it possible to have the pendulum bob touch the floor while it is still attached to the cord?

### Answer 3

### Instructions For Problem 3

There is a small handle attached to the other end of the pendulum cord after it passes through the support arm. You can pull or push on that handle to lengthen or shorten the distance that the pendulum bob is suspended. Using the mouse, drag the handle - also called "the ring" - up and down. Try it.

## Worksheet 7-2: Observing Pendulum Motion

Name: ______________________ Date: __________

Teacher: ______________________________

Class: ______________________ Score: __________

### What You Should Already Know

You should know how to change things around in the lab, especially the parts of the pendulum. Do Worksheet 7-1: **Working With The Pendulum** to learn how.

### Problem 1 - Simple Observation

Put the red bob on the end of the pendulum cord. Make the pendulum cord as long as possible. Pull the pendulum bob as high as it will go. Start the clock. Watch what happens. Describe what happens in a sentence or two.

### Answer 1

### Instructions For Problem 1

STOP the elapsed-time clock if it is running. Put the red bob on the end of the cord it is not already there. Push the cord handle as high as it will go toward the lab ceiling. Move the pendulum bob as high as it will go toward the ceiling. It should be horizontal when you are done. Start the elapsed-time clock.

**Problem 2 - Simple Hypothesis**

How will the motion of the pendulum change if we shorten the pendulum cord? Will the pendulum swing back and forth at a slower pace or at a faster pace? Write your guess below. At the same time give a short explanation of why you think it will swing faster or slower with a shorter cord.

**SPECIAL NOTE: It doesn't matter if your guess is right or wrong**, so don't worry about getting it "right". What counts is that you make the guess and try to back it up with information that you already know. Scientists often guess wrong, but that just makes them more curious, and leads them to learning new information about the behavior of objects. A scientific guess is called an **hypothesis** (HI - **POTH** - EH - SIS). Now make your hypothesis.

**Answer 2**

**Instructions For Problem 2**

DON'T do the experiment before you make your hypothesis. Try to come up with just one reason why you think it will behave the way you described.

**Problem 3 - Testing Your Hypothesis**

OK, now do the experiment. Shorten the pendulum cord as much as you can and observe the behavior of the pendulum. Describe what happens. Does it swing faster or slower when the pendulum cord is shorter?

**SPECIAL NOTE: Although you may have guessed correctly your reason may be wrong!** Later on we will do more experiments to determine the reasons why a pendulum does what it does.

**Answer 3**

**Instructions For Problem 3**

STOP the elapsed-time clock. Pull the cord handle all the way to the floor; the red pendulum bob should rise almost to the support arm. Move the bob up as far as it will go; it should be horizontal. START the elapsed-time clock. Record your observation.

## Worksheet 7-3: The Effects Of Mass

| | |
|---|---|
| Name:______________________ | Date:__________ |
| Teacher:______________________ | |
| Class:______________________ | Score:__________ |

### What You Should Already Know

You should know how to move things around in the lab. You should know how to make an hypothesis. See Worksheets 7-1: and 7-2: for helpful activities.

### Problem 1 - Mass of the pendulum bobs

Measure the mass of the red and blue pendulum bobs in grams. Write the results below.

### Answer 1

### Instructions For Problem 1

Drag the beam balance onto the lab bench. Put the pan (it looks like a dark black line on the icon) under the object whose mass you are going to measure. Don't get too far above or below the object or the mass will read 0.

**Problem 2 - Make An Hypothesis**

Which pendulum bob will swing faster? How much faster? Give at least one reason why you think this is going to happen.

**Answer 2**

**Instructions For Problem 2**

Try to figure out in your own mind if one of the pendulum bobs will swing faster than the other. Try to predict how much faster. It's much more useful to be able to say something like "eight times faster" then simply "faster." Write down a reason for your prediction.

**Problem 3 - Describing An Experiment To Test Your Hypothesis**

Make up a simple experiment to test your hypothesis. Describe the experiment that you plan to do in the answer box below.

**Answer 3**

**Instructions For Problem 3**

Think up a simple experiment to test your hypothesis that one of the pendulum bobs will swing faster than the other because....

Don't do the experiment just yet. Just write a couple of sentences about what you plan to do.

**Problem 4 - Doing The Experiment To Test Your Hypothesis**

Do the experiment that you described in your last answer. What did you get for a result? If you didn't get the results you expected, do any more questions come to mind?

**Answer 3**

**Instructions For Problem 4**

Write down the results you got, especially if they were not what you expected. In scientific experiments, one experiment usually leads to the next. Good experiments usually raise a lot of important questions.

## Instructions For Teachers

### I) With Regard To Teacher Participation

Thank you for helping Macro test and evaluate this courseware. The following information will show you how to proceed.

**Guiding You Through The Process**

1) Mark the **Checklist For Teacher Evaluation Of Courseware** as you go. Each teacher is provided with a **Checklist** to help organize his or her activities.

2) Examine the introductory materials and complete the form entitled **Teacher Evaluation Of Introductory Materials**.

3) Familiarize yourself with the Activity Worksheet Series, especially the Introduction to each experiment. Work with or observe students using the courseware materials. Complete the form **Teacher Evaluation Of Experiment** after you are thoroughly familiar with the materials and student reaction to a given experiment.

### II) With Regard To Student Participation

**Guiding Them Through The Process**

1) A **Checklist For Student Evaluation Of Experiments** is provided for each student who will be using the courseware materials. Check off the items on this list as the student completes them.

2) After a student completes the Activity Worksheets associated with a given experiment, have them complete the form **Student Evaluation Of Experiment**. Please have them do as many Activity Worksheets for each experiment as their ability allows.

### III) With Regard To Materials Organization

Two portable, hard-plastic file boxes are provided for storing the paperwork described above. Folders containing the relevant materials for 20 students are stored in the large file box, and materials for 5 teachers are located in the smaller file box. The teacher's file box should also contain a video tape labeled **Videos For The Physical Science Laboratory**, a plastic thermometer, and about 30 three by five cards.

The other half of this package is a large white three-ring binder labeled **TEACHER'S MANUAL** on the spine. It contains the software, Teacher's Manual itself, and the Activity Worksheet Series. There are nine 3½ inch disks tucked into labeled sleeves in the binder.

Please check to see that all the materials are intact when you receive them.

**ANY QUESTIONS ???????**

Please contact:

Garrett A. Hughes
Project Coordinator
Macro Systems, Inc.
126 College Street
Burlington, Vermont 05401
Telephone: (802)-863-9600

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Garrett A. Hughes
Project Coordinator
Macro Systems, Inc.
126 College Street
Burlington, Vermont 05401
Telephone: (802)-863-9600

## Checklist For Teacher Evaluation Of Courseware

Student Name: ______________________________

School: ______________________________ Grade: ______

**INSTRUCTIONS FOR THE TEACHER:**

Please put a check mark on the appropriate line when you complete complete each of the items listed below.

**Video Introduction**

Using A Mouse ______
Touring The Lab ______
A Sneak Preview ______

**Teacher's Manual**

Part I: Factors Influencing The Development .... ______
Part II: Operating The Physical Science Laboratory ______
Part III: Documentation And Support Materials ______
Part IV: Suggested Instructional Methodologies ______

**Experiment 0: The Physical Science Laboratory**

Introduction To Experiment 0: ______
Worksheet 0-1: Touring The Physical Science Lab ______
Worksheet 0-2: Using The Instruments ______
Worksheet 0-3: Using Other Instruments ______
Teacher Evaluation Of Experiment 0: ______

**Experiment 1: Finding Elapsed Time**

Introduction To Experiment 1: ______
Worksheet 1-1: Using The Elapsed Time Clock ______
Worksheet 1-2: Making Time Go Faster Or Slower ______
Worksheet 1-3: Time Sense ______
Teacher Evaluation Of Experiment 1: ______

**Experiment 2: Finding Length And Width**

Introduction To Experiment 2: ______
Worksheet 2-1: Using The Ruler ______
Worksheet 2-2: More Ruler Measurements ______
Teacher Evaluation Of Experiment 2: ______

### Experiment 3: Finding Area

Introduction To Experiment 3: ______
Worksheet 3-1: Area Of A Rectangle ______
Worksheet 3-2: Area Of A Circle ______
Worksheet 3-3: Area Of A Triangle ______
Teacher Evaluation Of Experiment 3: ______

### Experiment 4: Finding Distance Using A Map

Introduction To Experiment 4: ______
Worksheet 4-1: Measuring Map Distance ______
Worksheet 4-2: Measurement Issues ______
Worksheet 4-3: Ruler With 1/10 Inch Scale Divisions ______
Worksheet 4-4: Measuring Distances On Paper Maps ______
Teacher Evaluation Of Experiment 4: ______

### Experiment 5: Finding Seasonal Temperatures

Introduction To Experiment 5: ______
Worksheet 5-1: Measuring Air And Water Temperatures ______
Worksheet 5-2: Temperature Extremes ______
Worksheet 5-3: Changing Temperatures ______
Worksheet 5-4: Temperature Scales ______
Worksheet 5-5: Reading A Circular Thermometer ______
Teacher Evaluation Of Experiment 5: ______

### Experiment 6: Refrigerator

Introduction To Experiment 6: ______
Worksheet 6-1: Inside Your Refrigerator ______
Worksheet 6-2: Temperatures Inside A Refrigerator ______
Worksheet 6-3: Controlling Refrigerator Temperature ______
Worksheet 6-4: Knowing Your Refrigerator Thermostat ______
Worksheet 6-5: What If The Power Goes Off ______
Worksheet 6-6: Reading A Thermometer ______
Worksheet 6-7: In Your Own Refrigerator ______
Teacher Evaluation Of Experiment 6: ______

### Experiment 7: Pendulum

Introduction To Experiment 7: ______
Worksheet 7-1: Working With The Pendulum ______
Worksheet 7-2: Observing Pendulum Motion ______
Worksheet 7-3: The Effects Of Mass ______
Teacher Evaluation Of Experiment 7: ______

**Teacher Evaluation of Introductory Materials**

Name: ______________________________ Date: __________

School: ________________________________________________

Normal Teaching/Administrative Assignments: ______________

________________________________________________________

(In the space above, please give us an idea of what your current duties are. Include subjects, grade levels, or special assignments when appropriate.)

**INSTRUCTIONS:**

This evaluation will constitute your response to the introductory materials provided with the Physical Science Laboratory. Please familiarize yourself with those materials. Complete each Part of this form after you have become acquainted with the introductory materials discussed in each Part.

This evaluation consists of a series of statements about the introductory materials. For each statement, circle your level of agreement or disagreement on a scale of 1 to 5. A "1" indicates strong agreement, whereas a "5" indicates strong disagreement. A "3" indicates that you are essentially neutral on that topic. A section for your written comments is provided at the end of each category of questions. Thank you for your help in evaluating these materials.

| **Part I: Video Introduction** | Strongly Agree | | | | Strongly Disagree |
|---|---|---|---|---|---|
| 1. The video "Using A Mouse" provides good instruction in learning how to use a mouse. | 1 | 2 | 3 | 4 | 5 |
| 2. I would recommend the video "Using A Mouse" to another teacher for use as an instructional tool. | 1 | 2 | 3 | 4 | 5 |
| 3. I would use the video "Using A Mouse" to instruct students in how to use a mouse. | 1 | 2 | 3 | 4 | 5 |

4. The video "Touring The Lab" provides a good overview of the basic features of the Physical Science Laboratory. 1 2 3 4 5

5. I could describe the basic features of the lab to another teacher after viewing the video "Touring The Lab." 1 2 3 4 5

6. I would use the video "Touring The Lab" to instruct students in the basic features of the Physical Science Laboratory. 1 2 3 4 5

7. Having a person watch the video "A Sneak Preview" is a good way to introduce them to the simulated environments in the Physical Science Laboratory. 1 2 3 4 5

Additional comments on the video introduction:

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

(Use additional space on back if necessary.)

**Part II: Hands-On Introduction** Strongly Agree Strongly Disagree

8. The instructions in the Teacher's Manual for getting started with the hands-on materials are clear. 1 2 3 4 5

9. Starting up Experiment 0 did not present any significant problems. 1 2 3 4 5

10. Using the HELP feature is a convenient way to discover the names of objects and places in the Physical Science Laboratory. 1 2 3 4 5

| | | | | | |
|---|---|---|---|---|---|
| 11. Working through the Activity Worksheets for Experiment 0 is a good way to familiarize yourself with the lab's features. | 1 | 2 | 3 | 4 | 5 |

Additional comments on the hands-on introduction:

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

(Use additional space on back if necessary.)

| **Part III: Written Documentation** | Strongly Agree | | | | Strongly Disagree |
|---|---|---|---|---|---|
| 12. It is easy to find what you are looking for in the Teacher's Manual. | 1 | 2 | 3 | 4 | 5 |
| 13. The software's statement of purpose is clearly presented in the Teacher's Manual. | 1 | 2 | 3 | 4 | 5 |
| 14. The software's intended audience is clearly presented. | 1 | 2 | 3 | 4 | 5 |
| 15. The software's special features for the learning impaired are clearly presented. | 1 | 2 | 3 | 4 | 5 |
| 16. The software's intended goals for the student are clearly presented. | 1 | 2 | 3 | 4 | 5 |
| 17. The software's intended goals for the teacher are clearly presented. | 1 | 2 | 3 | 4 | 5 |
| 18. The software's hardware and software requirements are made clear. | 1 | 2 | 3 | 4 | 5 |
| 19. The glossary of mouse terminology is clearly presented. | 1 | 2 | 3 | 4 | 5 |
| 20. The glossary of Physical Science Laboratory terminology is clearly presented. | 1 | 2 | 3 | 4 | 5 |

Additional comments on the hands-on introduction:

______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________

## Teacher Evaluation of Experiment

Name:____________________________________ Date:____________

School:____________________________________________________

Normal Teaching/Administrative Assignments:_________________

____________________________________________________________

(In the space above, please give us an idea of what your current duties are. Include subjects, grade levels, or special assignments when appropriate.)

Special Education Certification:____________________________

____________________________________________________________

(In the space above, please list any certification that you have earned for instructing special education students)

Evaluated For Use With:_____________________________________

(In the space above, please indicate how you intend to use the software. Possible entries might be: group instruction in a computer lab; special education students receiving individual instruction; or resource room tool available on demand. Use back of this page to provide additional information)

Experiment Number: _____ Title:____________________________

**INSTRUCTIONS:**

You are evaluating the experiment listed above. This includes the computer simulation program, and the associated Activity Worksheets. Please be sure you have already completed the questionnaire entitled **Teacher Evaluation Of Introductory Materials.**

This evaluation consists of a series of statements about the instructional materials. Please respond to all of the statements that your training and experience qualify you to answer. For each statement, circle your level of agreement or disagreement on a scale of 1 to 5. A "1" indicates strong agreement, whereas a "5" indicates strong disagreement. A "3" indicates that you are essentially neutral on that topic. A section for your written comments is provided at the end of each category of questions. Thank you for your help in evaluating these materials.

| **Category A: General** | Strongly Agree | | | | Strongly Disagree |
|---|---|---|---|---|---|
| 1. The **Activity Worksheet Series Introduction** to this experiment clearly presents the educational objectives of this simulation. | 1 | 2 | 3 | 4 | 5 |
| 2. The important features of this experiment are thoroughly explained in the **Activity Worksheet Series Introduction.** | 1 | 2 | 3 | 4 | 5 |
| 3. The concepts presented in this computer simulation are well-suited for learning with the help of a computer. | 1 | 2 | 3 | 4 | 5 |
| 4. Use of this computer simulation along with the Activity Worksheets will accomplish the educational objectives stated in the **Activity Worksheet Series Introduction.** | 1 | 2 | 3 | 4 | 5 |
| 5. This computer simulation provides a needed learning tool for all students. | 1 | 2 | 3 | 4 | 5 |
| 6. This computer simulation provides a needed learning tool for the special education student when used in a special education instructional environment. | 1 | 2 | 3 | 4 | 5 |
| 7. This computer simulation is particularly well-suited to the learning needs of the mainstreamed special education student. | 1 | 2 | 3 | 4 | 5 |
| 8. This computer simulation provides a valuable teaching tool for teachers to use in an instructional environment. | 1 | 2 | 3 | 4 | 5 |
| 9. This computer simulation provides a valuable teaching tool for teachers to use in a special education instructional environment. | 1 | 2 | 3 | 4 | 5 |

Additional comments related to Category A:

(Use additional space on back if necessary)

| **Category B: Learning To Use This Program** | Strongly Agree | | | | Strongly Disagree |
|---|---|---|---|---|---|
| 10. A teacher with little or no computer experience could operate this program. | 1 | 2 | 3 | 4 | 5 |
| 11. Based on your observations, students with little or no computer experience could operate this program. | 1 | 2 | 3 | 4 | 5 |
| 12. The time required to learn how to operate just this program is less than 15 minutes. | 1 | 2 | 3 | 4 | 5 |
| 13. Students not classified as special education students had little or no difficulty using the mouse to control this simulation. | 1 | 2 | 3 | 4 | 5 |
| 14. Students classified as special education students had little or no difficulty using the mouse to control this simulation. | 1 | 2 | 3 | 4 | 5 |
| 15. The measurement instruments in this program were easy to use. (If one or more were difficult, please explain below) | 1 | 2 | 3 | 4 | 5 |

Additional comments related to Category B:

(Use additional space on back if necessary)

| **Category C: Graphics** | Strongly Agree | | | | Strongly Disagree |
|---|---|---|---|---|---|
| 16. The simulation's graphics are appropriate for the intended student audience. | 1 | 2 | 3 | 4 | 5 |
| 17. The simulation's graphics are appropriate for the task at hand. | 1 | 2 | 3 | 4 | 5 |
| 18. The simulation's graphics help focus the student's attention on the task at hand. | 1 | 2 | 3 | 4 | 5 |

Additional comments related to Category C:

(Use additional space on back if necessary)

| **Category D: Feedback** | Strongly Agree | | | | Strongly Disagree |
|---|---|---|---|---|---|
| 19. Students can understand the numeric measurements when they are displayed by the program in the value and units bars. | 1 | 2 | 3 | 4 | 5 |
| 20. Students can understand the numeric measurements when they are spoken by the computer. | 1 | 2 | 3 | 4 | 5 |
| 21. The capability to hide or display numeric measurements enhances the instructional use of this program. | 1 | 2 | 3 | 4 | 5 |
| 22. The capability to have the computer speak the numeric measurements enhances the instructional use of this program. | 1 | 2 | 3 | 4 | 5 |

| | | | | | |
|---|---|---|---|---|---|
| 23. Students can understand the HELP messages when they are displayed by the program in the HELP windows while using the HELP mode. | 1 | 2 | 3 | 4 | 5 |
| 24. Students find the HELP messages useful. | 1 | 2 | 3 | 4 | 5 |
| 25. Students can understand the HELP messages when they are spoken by the computer. | 1 | 2 | 3 | 4 | 5 |
| 26. The absence of value judgments (by the program to the student) actually enhances the instructional environment created by this program. | 1 | 2 | 3 | 4 | 5 |

Additional comments related to Category D:

(Use additional space on back if necessary)

| **Category E: Activity Worksheets** | Strongly Agree | | | | Strongly Disagree |
|---|---|---|---|---|---|
| 27. Students have little difficulty understanding the written instructions on the Activity Worksheets. | 1 | 2 | 3 | 4 | 5 |
| 28. Students are able to complete the Activity Worksheets with little or no help from the teacher. | 1 | 2 | 3 | 4 | 5 |
| 29. The time required to complete any one of the Activity Worksheets does not exceed the student's attention span. | 1 | 2 | 3 | 4 | 5 |
| 30. The Activity Worksheet problems are well correlated with the stated objectives for this simulation. | 1 | 2 | 3 | 4 | 5 |
| 31. There is a need for more of this type of software, which allows the teacher to design the problems for the student to solve. | 1 | 2 | 3 | 4 | 5 |

Additional comments related to Category E:

(Use additional space on back if necessary)

| **Category F: Instruction** | Strongly Agree | | | | Strongly Disagree |
|---|---|---|---|---|---|
| 32. Students are interested in the topic addressed by this simulation. | 1 | 2 | 3 | 4 | 5 |
| 33. Students would like to solve other problems in physical science using simulation. | 1 | 2 | 3 | 4 | 5 |
| 34. The computer simulation along with the problems posed by the Activity Worksheets provide an excellent learning environment for students. | 1 | 2 | 3 | 4 | 5 |

Additional comments related to Category F:

(Use additional space on back if necessary)

## Checklist For Student Evaluation Of Experiments

Student Name: ____________________

School: ____________________ Grade: ______

**INSTRUCTIONS FOR THE TEACHER:**

Please put a check mark on the appropriate line when the student completes each of the items listed below. When the student has completed ALL of the worksheets for a given Experiment, please have the student do the student evaluation of that experiment.

**Video Introduction**

Using A Mouse ______
Touring The Lab ______

**Experiment 0: The Physical Science Laboratory**

Worksheet 0-1: Touring The Physical Science Lab ______
Worksheet 0-2: Using The Instruments ______
Worksheet 0-3: Using Other Instruments ______
Student Evaluation Of Experiment 0: ______

**Experiment 1: Finding Elapsed Time**

Worksheet 1-1: Using The Elapsed Time Clock ______
Worksheet 1-2: Making Time Go Faster Or Slower ______
Worksheet 1-3: Time Sense ______
Student Evaluation Of Experiment 1: ______

**Experiment 2: Finding Length And Width**

Worksheet 2-1: Using The Ruler ______
Worksheet 2-2: More Ruler Measurements ______
Student Evaluation Of Experiment 2: ______

**Experiment 3: Finding Area**

Worksheet 3-1: Area Of A Rectangle ______
Worksheet 3-2: Area Of A Circle ______
Worksheet 3-3: Area Of A Triangle ______
Student Evaluation Of Experiment 3: ______

### Experiment 4: Finding Distance Using A Map

Worksheet 4-1: Measuring Map Distance
Worksheet 4-2: Measurement Issues
Worksheet 4-3: Ruler With 1/10 Inch Scale Divisions
Worksheet 4-4: Measuring Distances On Paper Maps
Student Evaluation Of Experiment 4:

### Experiment 5: Finding Seasonal Temperatures

Worksheet 5-1: Measuring Air And Water Temperatures
Worksheet 5-2: Temperature Extremes
Worksheet 5-3: Changing Temperatures
Worksheet 5-4: Temperature Scales
Worksheet 5-5: Reading A Circular Thermometer
Student Evaluation Of Experiment 5:

### Experiment 6: Refrigerator

Worksheet 6-1: Inside Your Refrigerator
Worksheet 6-2: Temperatures Inside A Refrigerator
Worksheet 6-3: Controlling Refrigerator Temperature
Worksheet 6-4: Knowing Your Refrigerator Thermostat
Worksheet 6-5: What If The Power Goes Off
Worksheet 6-6: Reading A Thermometer
Worksheet 6-7: In Your Own Refrigerator
Student Evaluation Of Experiment 6:

### Experiment 7: Pendulum

Worksheet 7-1: Working With The Pendulum
Worksheet 7-2: Observing Pendulum Motion
Worksheet 7-3: The Effects Of Mass
Student Evaluation Of Experiment 7:

## Student Evaluation of Experiment

Name: ______________________________ Date: __________

School: ______________________________ Grade: __________

Teacher: ______________________________________________

Class: ________________________________________________
(In the space above write the name of the class in which you are using this Experiment. For example: "General Science", "Physical Science", or "Ms. Worthy's class")

Experiment Number: ____ Title: _________________________

### INSTRUCTIONS:

We would like you to tell us a few things about the experiment whose number and title you wrote in the space above. Before you do, however, please complete one or more of the Activity Worksheets that go with this experiment.

Please read each sentence listed below. If you agree with the sentence, circle **Yes**, if you do not agree, circle **No**. If you cannot answer Yes or No, don't circle either one and go on to the next sentence. Thanks for taking the time to fill out this form.

1. I watched the video "Using A Mouse." Yes No
2. I watched the video "Touring The Lab." Yes No
3. One of my teachers explained to me how to run this experiment before I began doing it myself. Yes No
4. This was the first time I used a mouse to move things around on the computer screen. Yes No
5. I liked the way the objects were drawn on the computer screen. Yes No
6. Using the ruler instrument was easy. Yes No
7. Using the thermometer instrument was easy. Yes No
8. Using the scale (beam balance) was easy. Yes No
9. Using the car was easy. Yes No